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EVALUATION OF THE SOILS CONTAMINATION BY EXPLOSIVES AT CFB CHILLIWACK AND CFAD ROCKY POINT

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ABSTRACT

Following the decision of closing CFB Chilliwack, a sampling campaign was performed to evaluate the contamination by explosives at different demolition ranges. Three ranges, including Slesse, Vokes and the Soowahlie Rocket and Grenade Ranges were sampled using the pre-screening immuno-assay method but most of the collected soils and water samples were shipped to DREV for a thorough HPLC analysis. At the Slesse Range, the ion mobility spectrometry-based system developed by CPAD Technologies was evaluated and compared as a tool for the field screening of explosives in soils and water. The system worked but suffers strong limitations due to the quantity sampled and to the sensitivity of the detector. Most of the open detonation activities, including cratering, grenade, concrete, wood and steel cutting done at the ranges were evaluated and showed low levels of explosive contamination. Sampling from the White Phosphorus Burning Area revealed no contamination by explosives as expected. An exception was noted in the Ordnance Destruction Pits Area at Slesse Range where higher levels of contamination were observed. At CFAD Rocky Point, it was observed that the open burning of obsolete gun propellants is an incomplete process leading to residue accumulation and should be modified. Nitroglycerine analyses revealed important levels of contamination and heavy metals analyses showed lead concentrations higher than the level C threshold. Action is therefore required at that site. At the High Energy Open Detonation Site (Rocky Point), no contamination by explosives was found. Recommendations regarding all these sites were made.

RÉSUMÉ

À la suite de la décision de fermer la BFC Chilliwack, un campagne d'échantillonnage a été effectuée pour évaluer la contamination par les explosifs de différents sites de démolition. Trois sites, incluant Slesse, Vokes et les sites Soowahlie de tir antichar et de grenade furent échantillonnés en utilisant la méthode de pré-échantillonnage par immuno-essais, mais la plupart des échantillons de sols et d'eau ont été expédiés au CRDV pour être analysés par CLHP. Au site de Slesse,un système basé sur la spectrométrie par mobilité ionique et mis au point par CPAD Technologies a été évalué et comparé à titre d'outil pour l'échantillonnage sur place des explosifs dans les sols et l'eau. Le système fonctionne, mais souffre d'inconvénients majeurs dus à la quantité analysée et à la sensibilité du détecteur. La plupart des activités de détonation extérieure telles que la formation de cratères, les grenades, le coupage du ciment, du bois et de l'acier effectuées aux sites ont été évaluées et ont démontré des niveaux faibles de contamination par les explosifs. L'échantillonnage du site de brûlage de phosphore blanc n'a pas démontré de contamination par les explosifs tel qu'anticipé. Une exception a été observée dans les enclaves de destruction de munitions au site de Slesse où des niveaux de contamination plus importants ont été observés. Au DMFC de Rocky Point, on a observé que le brûlage extérieur de poudres à canon désuètes est un procédé incomplet conduisant à l'accumulation de résidues et qu'il doit être modifié. Les analyses de nitroglycerine ont montré des niveaux importants de contamination et les analyses des métaux lourds ont montré des concentrations de plomb plus élevées que le critère C. Une intervention est nécessaire à ce site. Au site de détonation extérieure des matériaux haute énergie de Rocky Point, aucune contamination par les explosifs n'a été constatée. Des recommandations concernant tous ces sites ont été faites.

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EXECUTIVE SUMMARY

The international context of demilitarization, increasing environmental importance of human activities, the closure of military bases, the increasing demand for new technologies for the clean-up of sites and the more severe aspects of the law to protect the environment, have led to the establishment of new areas for research and development. Many activities of the Canadian Forces such as firing, demolition and destruction of obsolete ammunition by open burning and open detonation may lead to the dispersion of energetic compounds in the environment. In Canada, limited effort has been spent to examine this particular environmental threat. Energetic compounds are just now being recognized as environmental contaminants as compared to other contaminants such as petroleum or solvents. Energetic compounds are unique due to their highly specific physical, chemical and toxicological properties.

It is within this context that the Defence Research Establishment Valcartier (DREV) initiated an R&D program in 1992 to study the environmental impact of energetic materials that are found in the DND ammunition stockpile. Another aspect of the DREV R&D program is the development of practical and economical remediation technologies for the cleaning of explosives-contaminated sites. Both programs on soil characterization and soil remediation will position the Department of National Defence in a state of readiness for any future potential contamination problems. DREV decided to develop biotechnologies as a remediation technique because these technologies are cheap, efficient, innovative and accepted by the public. To achieve that goal, DREV initiated a program with the Biotechnology Research Institute of the National Research Council of Canada to match their strong expertise in biotechnology with DREV's expertise in energetic materials. The research program consisted in identifying indigenous microorganisms capable of biodegrading energetic materials into less or ideally, non-toxic materials.

To understand the environmental impacts of explosives caused by the Canadian Forces activities, the characterization of all types of ranges was undertaken. Open burning/ open detonation sites, antitank, grenade, demolition, cratering, air-to-ground, ground-to-ground ranges etc.. were sampled using field screening method and a compositing technique to collect the soils and groundwater. When soils or groundwater were suspected to be contaminated by explosives, samples were collected and analyzed thoroughly in the laboratory using a high-pressure liquid chromatography (HPLC) method. Many ranges in many bases were then evaluated regarding their contamination by explosives. Since CFB Chilliwack had to be decommissioned in 1998, it was decided to assess the potential contamination in almost all of its ranges. On the other hand, we were tasked to evaluate the contamination by explosives at CFAD Rocky point. At both sites, minor problems were identified, except for the nitroglycerine and lead concentrations at the propellant burning area (Rocky Point). Recommendations to solve these problems were done. This report explains the approach taken at each site, the results and the final recommendations to mitigate the problems encountered on the ranges.

NOMENCLATURE

BFC	base des Forces Canadiennes
BRI	Biotechnology Research Institute
CFAD	Canadian Forces Ammunition Depot
CFB	Canadian Forces Base
CLHP	Chromatographie liquide haute pression
CRDV	Centre de recherches pourla défense Valcartier
DAPM	Director Ammunition Program Management
DGE	Director General Environment
DMFC	Dépôt de munitions des forces armées
DND	Department of National Defence
DRDB	Director Research & Development Branch
DUD	Unexploded ordnance resulting from a malfunction of the munition
DREV	Defence Research Establishment Valcartier
EOD	Explosive Ordnance Disposal
HE/OD	High Energy/ Open Detonation
HMX	Octogen or 1,3,5,7-Tetranitro-1,3,5,7-Tetrazocine
HPLC	High Pressure Liquid Chromatography
OB/OD	Open Burning/ Open Detonation
PBA	Propellants Burning Area
RDX	Hexogen or 1,3,5-Trinitro-1,3,5-Triazine
R&D	Research and Development
TNT	Trinitrotoluene

1.0 INTRODUCTION

It is a world-wide goal to identify and develop economical and effective methods to eliminate undesirable contaminants from soils and groundwater. This task is more complicated when the contaminants are energetic materials because of their crystalline properties and energetic characteristics. Energetic materials are the main components of gun powders, explosives warheads and solid rocket propellants and could therefore be found in war zones, training ranges or on industrial production sites. During this decade, many needs have already emerged related to the identification, quantification, delimitation and elimination of energetic contaminants dispersed by munitions or, present in explosives dumps, trials or destruction fields, firing areas and production sites (Refs. 1-2). The international context with the end of the Cold War resulted in the closing of many military bases and a growing awareness in environmental issues. It is within this context that the Director Research and Development Branch (DRDB) has directed some of its resources to assess the environmental risks associated with explosive compounds.

Many Canadian Forces sites such as impact areas, training ranges, demolition and open burning/open detonation (OB/OD) ranges which are used to destroy the out-of specification materials were highly suspected to be contaminated by energetic substances as described in the literature (Refs. 1-8). To evaluate the contamination of DND sites, sampling and characterization of various ranges was performed in the last five years and a protocol describing the different methods of sampling and the analytical chemistry was written (Refs. 9-11). All standard sampling, analysis and data management techniques should be applied when characterizing explosives contaminated sites (Refs. 12,13). One of the most important site to be sampled by DREV was the Canadian Forces Ammunition Depot, CFAD Dundurn, located in Saskatchewan (Ref. 1).

Since CFB Chilliwack was supposed to be closed in 1998 and the land given back to the natives, a thorough investigation related to the environmental impacts of all the possible contaminants was undertaken. We were tasked to evaluate the impacts related to energetic materials on most of the ranges of the base. At CFB Chilliwack, some ranges had already been given back to the natives. An Old Antitank Range where the soils had been moved and cleaned and an Old

Grenade Range were among the land recovered by the Soowahlie nation. These sites were sampled and analyzed and in one occasion in the presence of a native representative. Other ranges such as the Vokes Grenade Range, the Slesse Range, Mount Vedder Range were sampled using a compositing technique and analyzed with an immuno-assay field screening method. Contaminated soils were collected and sent to DREV for further chemical HPLC analyses. A system based on ion Mobility technology was also evaluated on the Slesse Range and compared with the field screening method to assess its potential as a screening tool for explosives in the soils and groundwater.

At CFAD Rocky Point, the situation was quite different. DAPM wanted to evaluate the possible impacts to the environment coming from the destruction of obsolete energetic materials by open burning. Since the storage of ammunition do not lead to important environmental problems, except when a broken casing is leaching the explosives through the soils, our efforts were concentrated to the burning areas.

This report describes all the work carried out between March 1996 and April 1997 at CFB Chilliwack and CFAD Rocky Point and the results obtained from the sampling campaign. This study was performed under the WU 2ng11, "Characterization of DND Sites Contaminated with Energetic Materials" and was sponsored by a task coming from Directorate of General Environment (DGE) through the Directorate of Ammunition Program Management (DAPM). Part of this work was done in collaboration with CPAD which owns the technology for the ion-scan detection of explosives and Adamas Environmental Inc. which used this technology on the site.

2.0 RANGE HISTORIC/DESCRIPTION

CFB Chilliwack is located in the Chilliwack vicinity, southeast of Vancouver, BC in the Fraser Valley. The following ranges are located close to the base: Slesse Range, Vokes Grenade Range, the Old Antitank Rocket Range and Old Grenade Range located on the Soowahlie reserve. Other ranges are located far from the base and comprise the Chilcotin Training Area, Stoney Creek Demolition Range in Trail, Goose Lake Training Area in Vernon and Vedder Peak Demolition Area. Among these sites, Mount Vedder was visited but not sampled. Slesse, Vokes, the old rocket and

grenade ranges were sampled. The other ranges were neither visited nor sampled due to a lack of time and low probability of finding energetic materials considering the history and area of the range.

2.1 Slesse Range

Most of our sampling study was done at the Slesse Range. This site has been used for demolition training since 1976. In 1989, the Slesse Demolition Training Area was expanded and an Ordnance Destruction Range was constructed below the terrace adjacent to Slesse Creek. The soils mainly consist of silts, sands and clays. The Slesse Demolition Area comprises two bunkers and a series of gravel pads, bays and earth mounds for demolition exercises and is illustrated in Figs. 1 A, B and 2. Activities at that range consist of demolition exercises such as cratering, steel, wood and concrete cutting. Cratering Area subsoils have been severely mixed and are of homogeneous nature to a depth of approximately 4 meters. Holes as deep as 6 feet were found in this area (Fig. 3). Steel Cutting, Concrete and Wood Demolition Areas have minor soil disturbances less than 1.5 meters in depth. There is also an area to destroy white phosporus by burning but this area was not extensively sampled. At the end of the White Phosphorus Area, there are explosives ordnance demolition pits that were sampled (Fig. 2A and 2C).

2.2 Vokes Grenade Range

This range is composed mainly of an explosion area where different types of grenades such as M-67, M-228, smoke and gas grenades were used, 6 pits in front of the blasting area of the range and a 600 meters rifle range. At that range, soils are similar to the Slesse Range soils and mainly consist of silts, sands, clays, varying sizes of gravel and small to large cobbles. No substantial solid clay formations exist in the underlying subsoils. The designated blasting area for the grenades has been bedded with sand to absorb the shock of the explosions as it can be seen in Figs. 4,5 and 6. In front of the grenade detonation area are the pits set aside to practice setting small charges of C-4. These C-4 charges are always used in small quantities. The 600 meters rifle range is used on a routine basis and is swept of metallic debris twice a year. This area was not sampled since small arm ranges might contain metals but no explosives.

2.3 Soowahlie Rocket and Grenade Ranges

These ranges designated in our study as the "Old Antitank Range and Old Grenade Range" had been transferred to the Soowahlie natives when we sampled in March 1996. This Rocket range was located on lands within the Soowahlie Indian reserve and was constructed in the late 1950's. The site was used until the end of the 1980's for antitank rocket training. It is located south of Chilliwack near Vedder Crossing, BC, and immediately west of the Vedder River within the original flood plain of the river. During the late 1980's, the Rocket Range Area was protected from flooding by the construction of an earth fill dyke that continues northward for more than a kilometer adjacent to the west bank of the river. In 1991, SNC Industrial Technologies Inc. and Geocon Inc. were tasked to evaluate soil contamination and provide recommendations for the future use and disposal of the stop butt soils. It is understood that, following clearance of the site, surficial soils were scraped from much of the eastern portion of the Rocket Range site and used in the construction of the flood control dykes. At our arrival, most of the soils were moved as it can be seen in Figs. 7 and 8. The sampling

Riske Creek, the Toosey Indian Band reserve number 1 and some ranches and homesteads. The training area was acquired by DND in 1924 and has been used four times a year for training purposes since 1960. Since that time, CFB Chilliwack, Canadian Forces School of Military Engineering has continued to conduct annual summer and fall demolitions and Field Tactical Exercises. Demolition exercises include cratering, route denial exercises and steel, wood and concrete cutting using mines, shaped charges, beehives, bangalore torpedoes and explosives such as C-4 and Trigran. These exercises are not performed at a particular location but can be everywhere. The geology of the area generally consists of deformed metasediments which have been extensively intruded with volcanic lavas. Much of the bedrock is covered with glacial deposits consisting of till, gravel, sand, silt and clay. The Chilcotin Training Area is still being used today by Small Unit Militia and Reserve Training. Unfortunately, it was not possible to visit and sample this site due to a tight timeframe.

2.5 Stoney Creek Demolition Range and Goose Lake Training Area- Vernon

The Stoney Creek Demolition Range consists of 510 hectares of land which was leased for five years. It was used by the 44th Field Engineering Squadron for demolition exercises and "dry" training maneuvers. Demolition exercises at this site occurred once or twice a year and involved only limited quantities of explosives. Moreover, except for the abatis exercises, cratering and steel cutting were limited to a designated range area. Since the activity at this site was limited and that approximately 20 kg/year were detonated at the site, it was neither visited nor sampled.

During World War II, Camp Vernon was used as a battle drill school and much of the area west and south of Vernon was an impact area for a variety of ammunition. It is possible that DUD explosives may still be present on and off of the training area as a result of military training activities. Two duds were found at Okeefe Ranch, north of Vernon and one was found in the Goose Lake Area in the vicinity of the Goose Lake Training Area. There were concerns about these duds. This site was not visited.

2.6 Vedder Peak Demolition Area

The Vedder Demolition Training Area consists of approximately 1,214 hectares of predominantly forested mountainous terrain and includes most of the land on Vedder Peak above the 457 m elevation contour. Since 1970, demolition activities such as cratering, steel, wood and concrete cutting and also basic charge laying took place at Mount Vedder. Military use of the training area was limited due to access restrictions caused by conflict with private land owners. The demolition training activities were restricted to designated areas near the peak of Vedder Mountain since these demolition exercises would have caused extensive damage to the vegetation. At the peak of the mountain, the impact was considered low because it was localized to limited areas where the soils were initially poor. Because of the potential impact that demolition exercises may have on watersheds in the area, DND ceased to use Vedder Peak for demolition training and changed for general training including bivouacking. When we visited this site, visual inspection proved that the impact would have been minimal, so it was decided not to sample Mount Vedder.

2.7 Open Burning/ Open Detonation sites at CFAD Rocky Point

CFAD Rocky Point is located close to CFB Esquimalt near Victoria on the Vancouver Island in British Columbia. It is a navy depot where, from time to time, old ammunition is destroyed by open burning/open detonation. The depot contains many storage buildings in the magazine area, but usually no contamination by explosives is found in storage compartments. We were tasked to evaluate the contamination by explosives at the Open Burning/ Open Detonation Areas so only these areas were sampled. The small White Phosphorus Burning Area was also sampled ($1 m^2$). The propellant burning area is 14 m x 24 m and there is a concrete pad surrounded by grass, this area is located in the middle of an earth mound (Figs. 12 and 14). Obsolete propellant grains are burned at this location. The other area of interest is the High Energy/Open Detonation Area where obsolete high energy compositions are open detonated. This area is located near the ocean and is shown in Figs. 13 and 15. The designated blasting area has been bedded with sand to absorb the shock of the explosions.

3.0 SAMPLING STRATEGY

During the sampling campaign, most of the soil and water samples collected were sent frozen to DREV for a complete HPLC analysis. Many samples were initially analyzed on the site using the Dtech immuno-assay, especially the samples collected at the Slesse Range. Some samples collected at the Soowahlie ranges were also analyzed with the Dtech test kits, but most of them were also sent to DREV. All the samples collected at the Vokes Grenade Range were not analyzed using Dtech but sent to DREV for a more complete analysis.

During the sampling of the Slesse Range, DREV worked in collaboration with Adamas Environmental Inc. to compare the results of explosive analyses in order to evaluate the potential of the ion mobility spectrometry technology as a tool for field screening. The objective of this trial was to determine the effectiveness of an apparatus designed to detect explosives in soil samples directly taken from a demolition site. CPAD Technologies developed equipment based on ion mobility spectrometry to detect explosives at very low levels and such instruments are now in use in airports to detect explosives. They adapted their instrument for soils sampling. Originally, the design was done for mine detection applications. This equipment was set on a mobile unit owned by sub-contracted Adamas Environmental Inc. and run at the Slesse Range. All the results of this study can be found in the literature (Ref. 14).

3.1 Sampling of the Slesse Range

This range is the largest site sampled. It was divided into regions related to the activity of these particular spots such as the Cratering Area (S1-S17), the Concrete Cutting Area (S18-S21), the Wood Cutting Area (S27-S30), the Steel Cutting Area (S31-S37) and the Explosives Ordnance Disposal (EOD) Area. All the results related to the Slesse Range can be found in Table I. The Cratering Area contained many big craters, five of them were sampled according to the grid illustrated in Fig. 2B. The bottom and the walls of the craters were sampled to build a composite sample out of 8-10 sub-samples and were named Crater BW. Surrounds of the craters were also sampled building composite samples and named Crater S. The entire area was sampled by regions

and named Region I to IV by building composite samples out of 15 sub-samples. Most of the Dtech detection test kits were used in this area of the range and the results were compared with those obtained using the ion mobility spectrometry provided by Adamas Environmental Inc. Adamas analyzed 114 samples on site, they collected 65 composite samples and 14 core samples to evaluate their technology (Ref. 14).

The Concrete, Wood and Steel Cutting Areas were sampled according to the scheme illustrated in Fig. 2B and 2D. All the samples were built from 10 sub-samples to obtain composite samples that were sent to DREV for analysis. The Concrete and Wood Cutting Areas were sampled at four and five locations named C1 to C4 and W1 to W5. The earth mound was also sampled. In the Wood Cutting Area, there were three small areas where pyrotechnics were fired, these areas were sampled and mixed to form the W 6. The Steel Cutting Area was composed of six spaces located between earth mounds. The bottom and the walls of these spaces were sampled. There were also some small trenches where the surface water was going down to the Slesse Creek. These surface water collection trench samples were collected and named Trenches 1 to 3 (Fig. 2B). Many water samples were taken at different positions between the range and the Creek as shown in Fig. 2B and sent to DREV. The Explosives Ordnance Disposal Areaconsisted of 6 pits. Pit 1 and 6 were not sampled since no activity was conducted in these pits and they were looking clean. The other pits were sampled by collecting composite samples at the bottom and in the walls of the pits, depending of the dirt seen in each of these pits. This time the samples were differentiated as EOD bottom and EOD walls. Two samples were also collected in the White Phosphorus Area named EOD WP Areas A and B Fig. 2C.

3.2 Sampling of the Vokes Grenade Range

method is illustrated in Fig 6. The pits at the back of the range were sampled by building a composite sample since the surface of the pits was to small to use the wheel pattern. The first pit was not sampled because it was not disturbed. All these samples were sent frozen to DREV without doing analyses in the field. All the results are shown in Table II.

3.3 Sampling of the Soowahlie Rocket and Grenade Ranges

Usually, sampling antitank range is done close to the targets using the Wheel Pattern compositing method described in Ref. 11 but, since there was only one target and since the surface soils had been moved, the compositing approach was chosen. The sub-samples were randomly taken to improve the chances of having positive hits at different locations shown in Fig 9. For the Grenade Range, the Wheel Pattern method was used for the 6-inch deep samples at four locations shown in Fig 11 and named Deep A to D. The surface samples were collected in the quadrant by building a composite sample. These were named Surfaces A to D. It was very difficult to build the wheel since there were many rocks in the soils and the soil was very hard. All the samples were sent to DREV and the results are found in Table III. While we were sampling the Grenade Range, an Indian chief came to ask questions about possible contamination of his drinking water by explosives. A delicate situation took place and we asked him to provide us with a water sample that was analyzed in front of him. No explosives were detected in this water sample.

3.4 Sampling of CFAD Rocky Point

At CFAD Rocky Point, three locations were tested for explosive contamination, the Propellant Burning Area, the High Energy Open Detonation Area close to the Christopher Point and the small White Phosphorus Burning Area. The magazine area was not sampled since usually, no contamination is observed in storage buildings. The Propellant Burning Area was located between earth mounds as shown in Figs. 12 and 14. It contains a concrete pad surrounded by grass. The grass surface at the Propellant Burning Area was divided into sections, as shown in Fig. 12. PBAs 1 to 3 samples were built from 8 sub-samples. PBAs 4 to 12 samples were collected using the Wheel Pattern method. PBA 8 and PBA 13 were not collected since the soils were too hard. The High

Energy/ Open Detonation Area is a small area close to the ocean where obsolete high energy materials are open detonated (Fig. 15). There were three areas often used for OD, two of these spots presented a crater caused by recent OD of munitions. These areas were numbered 1 to 3 and the craters were sampled using the Wheel Sampling approach (Fig. 13). All samples collected at CFAD Rocky Point were shipped directly to DREV without doing any pre-screening test kits for a thorough HPLC analysis.

4.0 EXPERIMENTAL

4.1 Chemical Suppliers

Field screening enzyme immuno-assay test kits used for the detection of RDX and TNT were obtained from Strategic Diagnosis Inc. The determination of the signals was achieved with a Dtech detector especially constructed for the immuno-assay test kits and purchased from the Dtech company. All standard explosives analytes for EPA 8330 method were obtained from Accustandard (Ref. 15). All solvents were purchased from Fisher Scientific Co., except for anhydrous ethanol, which was obtained from "Les alcools de commerce limitée". All-purpose acetone was obtained from Anachemia as reagent grade. Methanol used to prepare HPLC eluents was Sigma-Aldrich HPLC grade. Laboratory grade water used for preparation of HPLC eluents was obtained from a Millipore Milli-Q Type 1 reagent grade water system. Reagent grade chemicals were used to perform the salting-out procedure for water samples. HPLC laboratory analyses performed at DREV were done with a Hewlett packard HP Model 1090 equipped with a diode array UV detector HP Model 1100.

4.2 Soils and Water Samples Collection

At CFB Chilliwack and CFAD Rocky Point, all the soils and surface water samples were collected by DREV personal. The materiel to collect the sample was washed with acetone, rinsed with water and dried before taking the next sample to avoid cross-contamination. In many cases, the Wheel Pattern collection method was used, this method is described in Ref. 11 and allow to collect

a homogeneous sample. When the wheel pattern was not applicable, a composite sample was formed from at least 10 and sometime up to 20 sub-samples. Commercially available field screening method (enzyme immuno-assay) was used to identify the contamination on the site. Complete description of this method and the way to use it can be found in Ref. 11. When positive identification was obtained, these contaminated soil samples were put into plastic bags (Ziploc type) and sent frozen to DREV to be analyzed using the HPLC method 8330. For the water analyses, samples were put into jars and sent to DREV for a thorough analysis. Some blank samples were also collected and sent to DREV for the quality control and to assess the different types of soils that were encountered and collected at both sites.

4.3 Sample Treatment and Laboratory Analysis

All soil and water samples that gave a positive response to the immuno-assay tests were collected in plastic bags or jars kept cold or frozen and in the dark until they were shipped to DREV for analysis by the HPLC method. This HPLC method is described in great detail in Ref. 11. Once received at DREV, each soil sample in a Ziploc bag was shaken and kneaded, then emptied into aluminum pans. The soils were further homogenized by breaking up clumps with gloved hands and stirring. The soils were extracted with acetonitrile by sonication and the extracts were analyzed as described in the EPA HPLC method 8330 (Ref. 15).

5.0 RESULTS AND DISCUSSION

At CFB Chilliwack, most of the work was done at the Slesse Range, Vokes Range, and at the Soowahlie Rocket and Grenade Ranges. Most analyses for the soil and water contamination by explosives were performed using the HPLC method 8330 and these results can be found in Tables I to III. An important part of the work was the evaluation of the ion mobility spectrometry detector coupled with gas chromatography. This technology was originally developed by CPAD technologies for the detection of traces of explosives in airports, but the prototype used on site was a modified version that detected explosives in soils at the ppb levels. In fact, the system was developed for the detection of explosives in soils to find buried landmines. A complete description of the prototype

apparatus can be found in Ref. 14. It was thought by CPAD that the ion mobility detector could be applied to the detection of explosives in soils to screen the contamination in environmental studies. So, this system was mounted on a mobile unit that was sent to the Slesse Range and operated by Adamas to evaluate the potential of this technology in the field. The results of this study was published by CPAD technologies and can be retrieved in their final report (Ref. 14).

5.1 Characterization of the Slesse Range

This site was the most studied range among CFB Chilliwack ranges. Most of our efforts were directed to the Cratering Area where field screening immuno-assay test kit results were compared with the results of the ion mobility spectrometry performed by CPAD/Adamas. Most of our samples were sent to DREV for analysis by HPLC. The ion mobility spectrometry proved to be applicable but suffers strong limitations. It has to be understood that the explosives are crystalline compounds dispersed in the environment leading to a heterogeneous situation. To compensate for this particularity of explosives, the Wheel Pattern or at least the compositing approach were developed and applied to the sampling of explosives. This resulted in representative results when sufficient quantities of soils are collected and composited, as observed in Refs. 10 and 11. The ion mobility analysis is performed using a sifting technique that introduces milligrams of materials in the apparatus. This quantity is relatively small compared to the HPLC requirement (2 g) which is selected from a 200 g composite sample and therefore can not be representative of the surface analyzed. Moreover, this technology was developed to detect traces of explosives and, therefore, the limit of detection is exceptionally low, even lower than the HPLC method. This resulted in positive responses at almost every sample even at very low concentrations (ppb). Furthermore, since the apparatus was developed to detect ppb levels of contaminants, positive responses at the ppm level saturated the apparatus for hours. As a result, a cleaning process of the system had to be done for hours. So, it was worth to evaluate the ion mobility detector in the field but the technology was not applicable unless important modifications to the apparatus are done.

By examining Table I, it is observed that HMX was not found in the Cratering Area, probably because TRIGRAN and C4 contains only small quantities of HMX. RDX was found at a maximum

concentration of 4.4 ppm, which is relatively low and TNT at 18.10 ppm. There were some concerns that toxic gas released by the detonation of explosives would be toxic if inhaled and that the persistence and affect of these fumes was not known but would be a function of the local climate/weather characteristics of the valley such as wind speed and patterns. It has to be mentioned that demolition is an open detonation of explosives. Studies done at CFAD Dundurn by DREV and studies at the Nevada site done by the United States demonstrated that the open detonation is a clean process where the gaseous emissions are not toxic (Refs. 1 and 16). When the open detonation is done with a critical mass of explosives, a complete combustion occurs and no impact to the environment is observed. For this reason, most of the sites where demolition exercises are done showed low levels of contamination by explosives.

The Concrete, Wood and Steel Cutting sites demonstrated low levels of contamination with the highest concentrations being at 6.16 ppm for RDX, 0.37 ppm for TNT and 0.30 ppm for HMX. These levels of contamination does not represent an environmental issue especially since they are found in only two locations S-32 and S-34 in the Steel Cutting Area. It is possible that a bad deflagration/detonation of C4 resulted in these levels of contamination. Nevertheless, no action is required with these low levels of contamination.

There were some concerns about the environmental impacts of the explosives related to the water quality of the Slesse Creek. Slesse Creek supports chinook, coho, chum and pink salmon and steelhead trout at different life stages of the fishes. The Chilliwack River hatchery is located just upstream of the confluence of Slesse Creek with the Chilliwack River and therefore, no direct impact caused by the range activities should be observed. On the other hand, smolts from the harchery are released into Slesse Creek and would be affected if severe impacts from the range would be observed but this is not the case. Important contamination by explosive was not found either on the range soils or in the surface water. Many surface water samples were collected in trenches that were leading to the Creek and neither the surface water samples nor the water samples collected from the Creek showed contamination at the ppb levels (Fig. 2B). Moreover, if explosives were leaching from the range to the Slesse Creek, it would be in a very small concentration and in this case, infinite dissolution would occur when reaching the Creek. Therefore, no adverse impacts to the fishes and water quality are anticipated at this location.

Evaluation of the contamination by explosives in the Ordnance Disposal Pits revealed higher levels of explosives in many cases. Based on results of Table I, there are no trends that can be observed between the concentration at the bottom or the walls of the pits. Highest concentrations of explosives were found in pits 3 and 5 for HMX, RDX and TNT. No value exceeded 100 ppm, the highest value being 85.47 ppm for RDX in pit 5. These concentrations are high but the quantity of contaminated soil is small. There are no accepted health risk or ecotoxicological criteria for explosives available in this country. So, nobody can tell how clean is clean and at which level the remediation should stop. The United States evaluate each site doing a site risk assessment which is costly. In some occasions, they stopped cleaning the site at 10 or 100 ppm leaving natural attenuation as a natural process to remove the residual concentrations.

In this case, the concentrations are not exceeding 100 ppm, human receptors are far away from the site and nobody is drinking the groundwater. It is not believed that the leaching of these levels of explosive concentrations through the groundwater and to the Creek can have adverse effects on the fishes or water quality. Furthermore, the quantities of soils being small and the distance to reach the Creek being relatively important, it is thought that the explosives will leach with time through the groundwater, being diluted to infinity and biotransformed or mineralized. Since this process is slow, natural attenuation should occur and no adverse effects should be observed for the water quality. It is therefore recommended that no action be taken with these soils. However, if the land is given back to the public or if an action must be taken for any reasons, considering the amount of soils, one should consider sending them to incineration before disposal. The analyses for the White Phosphorus Area samples revealed negligible concentrations as expected.

5.2 Characterization of the Vokes Grenade Range

As described earlier, this range was composed of an explosion blasting area and 6 pits at the back of the range. The main blasting area was divided into 6 sections. By analysing Table II, one can see that the contamination is quite low varying from not detected to 1.02 ppm of RDX and 0.53 ppm HMX. These concentrations are considered negligible and are representative of an open detonation

site. In the pits, low concentrations were also observed, the highest concentration being 2.75 ppm for RDX. Since the concentrations in explosives in the main blasting area and in the pits are low, no action is required at this site. The rifle range was not sampled because no explosives are found in such sites.

5.3 Characterization of the Soowahlie Rocket and Grenade Ranges

By examining Table III, one can see that the contamination by explosives at the Old Antitank Range is minimal since only one hit was obtained with the OAR-3 sample and this was anticipated. Since all the soils were moved, the explosives were dispersed by mixing and this lowered their contamination. The problematic of antitank ranges is well known now and was documented (Ref. 2). The use of M-72 Rocket leads to the spraying of HMX and TNT on the soils of antitank range because of the high DUD rate of this munition. This results in high levels of HMX in these sites. The fact that the site was probably flooded by the river from time to time before the construction of the dyke in the late 1980's helped the explosive residues to be washed away by dissolution. So, in 1991, when SNC Technologies cleaned the schrapnels from the site doing the level 1 clearance and moved the soils, the contamination was probably initially very low. Also, moving the soils reduced a lot the concentration since the contaminated soils are diluted by clean soils resulting in lower concentrations. This was confirmed by our analyses. As an example, we removed the first 18 inches of top soils in an antitank range that were contaminated at 3000 ppm by HMX and after the collection of the soils to build a biopile, the overall concentration was only 150 ppm (Ref. 17). As a consequence, the contamination, if there was some, can have been diluted and is long time gone. Therefore, no action is required at that site.

The Old Grenade Range represents a problematic similar to the situation encountered at the Vokes Grenade Range. Table III revealed that no contamination is detected at that range, except for the sample OG-6 in which the concentrations are respectively 1.16 and 3.11 for HMX and RDX. As it was seen earlier, open detonation did not lead to high levels of explosive residues and the situation at the Old Grenade Range is similar to demolition and open detonation ranges. Therefore, no action is needed for this site.

5.4 Characterization of the Other Ranges of CFB Chilliwack

As mentioned earlier, the other ranges were not sampled because of the lack of time. Many questions were asked about the Chilcotin Training Area and some answers could be given. At that site, the demolition exercises can be performed everywhere since no specific location was attributed as an example for the cratering exercise. According to the Tl'esqox (Toosey) Indian Band's Preliminary Report on "Environmental Impacts of Canadian Military Training Exercises", 436 craters were documented at 96 damaged areas in the grasslands (50 km^2). The natives raised concerns about the toxicity, the bioaccumulation of explosives and the impacts to their environment. As it was seen in this report, open detonation and demolition lead to low concentrations of explosives in the soils, even when the activity is concentrated at a specific spot for years. Due to the size of the Chilcotin Training Area and the relatively few craters since there is no specific location for this activity, it is our belief that the situation of the Chilcotin Training Area is comparable to the other sites and that no action is required. For Mount Vedder, Stoney Creek in Trail and Camp Vernon-Goose Lake Training Area, we do not anticipate any problems related to the contamination by explosives and the situation should be similar to the other training areas.

5.5 Characterization of CFAD Rocky Point

Two sites were sampled at CFAD Rocky Point. The Propellant Burning Area and the High Energy/ Open Detonation. All the soils samples collected at the Propellant Burning Area were analyzed at DREV using the HPLC method 8330 and revealed no traces of explosives. Since the propellants burned at that location are obsolete gun propellants, this situation is normal. Most of the obsolete gun propellants are simple, double or triple base propellants. These propellants contain no RDX, HMX or TNT but are made of nitrocellulose, nitroglycerine and nitroguanidine.

At the time we visited the site, it was quite dirty having many partially burned propellant grains all over the grass as can be seen in Fig. 16. When we were sampling the site, a strong organic odor corresponding to nitroglycerine was present and gave us headaches indicating that this site was

contaminated by nitroglycerine. In these years, many efforts were done to analyze nitrocellulose and develop its analytical chemistry (Ref. 18). Nitrocellulose is difficult to analyze because it is a polymeric compound almost insoluble and it is not toxic because the nitro groups hinder the enzymatic sites preventing the biodegradation by microorganisms. Nitroglycerine and nitroguanidine analytical chemistry was not well developed at this time but work using a new method developed by CRREL for nitroglycerine was available (Ref. 19). This method used a gas chromatography coupled with an electron capture detector. A portion of all the propellant burning area samples was sent to CRREL for nitroglycerine analysis. Table IV showed that PBA 4, 5, 6, 11 and 12 are contaminated by nitroglycerine at levels as high as 90 ppm. The most contaminated samples were located on each side of the concrete pad where the propellants are most often burned. PBA-12 contained the highest concentration and was located directly under the unburned propellant grains illustrated in Fig. 16.

Since the site was dirty indicating incomplete combustion, another portion of all the samples was sent to a private firm for heavy metals and polycyclic aromatic hydrocarbons (PAH) analysis. Usually, when combustion is incomplete, PAH are formed and black residues are found on the ground. The burning process itself is not a complete chemical reaction. In comparison with the open detonation, the temperature of the burning process is quite low, preventing the reaction to end with the desired combustion products carbon dioxide, water and nitrogen. Moreover, at CFAD Rocky Point, the weather conditions often consist of rainy days. That rain sometimes stops the burning reaction by wetting the grain or by lowering the temperature of the reaction. This led to incomplete reaction with a great amount of residue (partially burned propellant grains). The rain can help the components like nitroglycerine to infiltrate the ground and give this strong organic odor. If you can smell it, you probably have enough concentration of nitroglycerine to generate a safety concern.

Furthermore, the propellant grains were burned directly on the grass instead of burning the propellants on the concrete slab. Using the concrete slab would be better, easier to clean and less problematic for the environment. A good alternative to the burning of the propellants directly on the ground was exposed recently at a symposium in Florida (Ref. 20). An apparatus was built to burn the propellants and consisted of a steel box equiped with many propane burners. This system ensures

that the combustion will be complete after the treatment. Such a system would be beneficial for the disposal of obsolete propellants at CFAD Rocky Point.

"Laboratoire de génie sanitaire du Québec" performed all the analyses for the heavy metals detection and PAH's. These results are found in Annex 1. By examining the results, it is observed that most of the heavy metals present in the soils at the Propellant Burning Area are below the level C threshold criteria (industrial use) most often at the background level (level A). In some occasions, values higher than the level B criteria were found (residential use). An exception is noted for the lead concentrations that exceed by far the level C criteria. Lead is a human health hazard and at these levels (level C= 1000 ppm in the province of Québec), an action is required. The highest lead concentrations are found everywhere around the concrete pad on the site, and more precisely at PBA 11 and 12 where the unburned propellants were observed. The concentrations for PBA-4 to PBA-12 varied from 77 to 220,000 ppm. This contamination should be investigated more in depth to evaluate the quantity of contaminated soils. One should keep in mind that nitroglycerine is present in these soils and therefore, caution must be exercised during the drilling, sampling and removal of the soils. Usually, when the level C criteria is trespassed, soils are chemically treated or sent to a secure landfill. All analyses for PAH revealed low concentrations below level B criteria (residential use).

A similar problem is encountered at the White Phosphorus Burning Area where lead, copper and zinc concentrations exceeded level C criteria. Fortunately, no explosives were detected in the sample as this is usual for white phosphorus burning sites. Nonetheless, these soils must be removed. At the High Energy/Open Detonation Area, all samples revealed no traces of explosives as this is often the case for open detonation. The heavy metals and the PAH's analyses showed that the concentrations were at the background level (level A) or below the level B criteria. No action is needed at this location.

Therefore, it is recommended that the open burning of obsolete gun propellants be done on the concrete slab instead of directly on the grass, that the burning be done when it does not rain and that the slab be cleaned once in a while to prevent explosive residues to be in contact with the soils. We would recommend that a system to burn the propellants similar to the one shown in Ref. 20 be

constructed or acquired. We also recommend that the situation encountered with the heavy metal and nitroglycerin concentrations be investigated more in depth. We believed that an action is required to solve this problem which could represent an health and safety issue.

6.0 CONCLUSION AND RECOMMENDATIONS

Most of the local ranges at CFB Chilliwack were sampled for the detection of contamination by explosives. Pre-screening immuno-assay method was used in the field but most of the samples collected on the ranges were sent to DREV for a thorough HPLC analysis. Three ranges were sampled including Slesse Range that was the most characterized site, the Vokes Grenade Range and the Soowahlie Rocket and Grenade Ranges. Mount Vedder was visited but not sampled. At Slesse Range, the ion mobility spectrometry technology developed by CPAD was tested to evaluate its potential as a screening tool for explosives in soils. The technology worked well but strong limitations were encountered and important modifications to the system would be necessary to apply this technology to the field.

In general, it has been demonstrated that open detonation including all the activities such as cratering, wood, concrete and Steel Cutting showed low levels of contamination by explosives proving that this is a clean process. This had been also observed at CFAD Dundurn. Since the contamination is low, it was recommended that no action be taken on these sites. Only one exception was observed at the Ordnance Destruction Pits where higher levels of explosives were found. In this case, it was evaluated that the impact to the environment is minimal and that the soils should be left alone. If an action has to be taken, incineration of the soils is recommended.

At CFAD Rocky Point, it was observed that the open burning process at this location is a dirty process that needs improvements. It was also observed that high levels of lead and nitroglycerine are found on the site. It was recommended that the open burning of obsolete gun propellants be done using the concrete slab instead of burning the propellants directly on the grass. It was also recommended that the burning be done when it does not rain or when the weather conditions are favorable. It was recommended that the concrete slab be cleaned to avoid the

explosive residues to contaminate the soils surrounding the concrete slab leading to a potentially dangerous situation. The building of a unit to burn the propellants should be more than appropriate. We also stated that a thorough investigation should be performed to solve the heavy metals and nitroglycerin problem at the Propellant Burning Area and also at the White Phosphorus Burning Area. The High Energy Open Detonation Area did not show any contamination by explosives as observed with other open detonation areas. No action is required at that site.

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TABLE I

Explosive Soil Concentrations at Slesse Range

AREA	SAMPLE	REPLICATE	[HMX] ppm	[RDX] ppm	[TNT] ppm
Cratering					
Crater 1 (BW)	S-1	A	n.d.	0.42	0.25
		B	n.d.	0.75	0.23
		C	n.d.	0.62	0.31
Crater 1 (S)	S-2	D-TECH	n.d.	n.d.	n.d.
Crater 2 (BW)	S-3	D-TECH	n.d.	n.d.	n.d.
Crater 2 (S)	S-4	D-TECH	n.d.	n.d.	n.d.
Crater 3 (BW)	S-5	D-TECH	n.d.	n.d.	n.d.
Crater 3 (S)	S-6	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
Crater 4 (BW)	S-7	A	n.d.	0.44	0.29
		B	n.d.	0.40	0.75
		C	n.d.	0.42	18.10
Crater 4 (S)	S-8	D-TECH	n.d.	n.d.	n.d.
Region I	S-9	D-TECH	n.d.	n.d.	n.d.
Region II	S-10	A	n.d.	0.04	0.20
		B	n.d.	0.04	0.46
		C	n.d.	n.d.	0.18
Region III	S-11	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
Region IV	S-12	A	n.d.	1.17	0.24
		B	n.d.	0.64	0.16
		C	n.d.	0.86	0.10
Trench 1	S-13	A	n.d.	0.38	n.d.
		B	n.d.	0.44	n.d.
		C	n.d.	0.35	n.d.
Trench 2	S-14	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
Crater 5 (BW)	S-15	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.

AREA	SAMPLE	REPLICATE	[HMX] ppm	[RDX] ppm	[TNT] ppm
Crater 5 (S)	S-16	A	n.d.	n.d.	0.14
		B	n.d.	n.d.	0.02
		C	n.d.	0.21	1.61
Trench 3	S-17	A	n.d.	3.8	n.d.
		B	n.d.	4.4	n.d.
		C	n.d.	3.5	n.d.
Concrete Cutting					
C 1	S-18	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
C 2	S-19	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
C 3	S-20	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
C 4	S-21	A	n.d.	0.01	n.d.
		B	n.d.	0.03	n.d.
		C	n.d.	0.05	n.d.
Wood Cutting					
W 1	S-22	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
W 1	S-23	A	n.d.	0.45	n.d.
		B	n.d.	0.53	n.d.
		C	n.d.	0.51	n.d.
W 2	S-24	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
W 2	S-25	A	n.d.	1.23	n.d.
		B	n.d.	0.66	n.d.
		C	n.d.	0.60	n.d.
Earth mound	S-26	D-TECH	n.d.	n.d.	n.d.
W 3	S-27	A	n.d.	0.47	n.d.
		B	n.d.	0.49	n.d.
		C	n.d.	0.60	n.d.
W 4	S-28	A	n.d.	0.52	0.37
		B	n.d.	0.72	0.31
		C	n.d.	0.65	0.30
W 5	S-29	A	n.d.	0.35	n.d.
		B	n.d.	0.40	n.d.
		C	n.d.	0.32	n.d.

AREA	SAMPLE	REPLICATE	[HMX] ppm	[RDX] ppm	[TNT] ppm
W 6	S-30	A	n.d.	0.44	n.d.
		B	n.d.	0.68	n.d.
		C	n.d.	0.46	n.d.
Steel Cutting					
Area 1	S-31	A	n.d.	0.07	n.d.
		B	n.d.	0.10	n.d.
		C	n.d.	0.26	n.d.
Area 2	S-32	A	0.20	2.78	n.d.
		B	0.30	5.94	n.d.
		C	0.16	4.19	n.d.
Area 3	S-33	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
Area 4	S-34	A	n.d.	2.31	n.d.
		B	n.d.	0.42	n.d.
		C	n.d.	6.16	n.d.
Area 5	S-35	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
Area 6	S-36	A	n.d.	0.04	n.d.
		B	n.d.	0.04	n.d.
		C	n.d.	0.05	n.d.
Area 7	S-37	A	n.d.	0.15	n.d.
		B	n.d.	0.37	n.d.
		C	n.d.	0.29	n.d.
Ordnance Disposal Pits					
	EOD-2 Bottom	A	2.83	0.43	n.d.
		B	8.22	1.92	n.d.
		C	0.74	0.08	n.d.
	EOD-2 Wall	A	0.83	10.42	1.47
		B	1.04	12.90	0.71
		C	0.14	4.07	0.71
	EOD-3 Bottom	A	48.46	9.09	50.09
		B	45.78	12.07	1.52
		C	23.66	65.42	1.19
	EOD-3 Wall	A	12.36	83.61	2.44
		B	16.02	67.79	2.45
		C	25.88	83.83	4.48
	EOD-4 Bottom	A	3.07	11.48	1.32
		B	2.74	11.45	1.04
		C	1.76	11.23	1.51

AREA	SAMPLE	REPLICATE	[HMX] ppm	[RDX] ppm	[TNT] ppm
	EOD-4 Wall	A	2.11	11.98	1.22
		B	4.74	13.47	1.10
		C	2.70	11.21	1.07
	EOD-5 Bottom	A	7.16	85.47	16.62
		B	5.30	51.10	3.53
		C	3.94	39.32	3.19
	EOD-5 Wall	A	10.04	61.40	9.63
		B	6.87	49.28	14.65
		C	20.03	44.69	6.69
	EOD WP Area A	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
	EOD WP Area B	A	n.d.	n.d.	n.d.
		B	n.d.	1.24	n.d.
		C	0.23	n.d.	n.d.

n.d. : not detected
D-TECH : pre-screening immuno-assay test kit analysis
All the HPLC analyses revealed no explosives in the water samples collected at the Siesse Range

TABLE II

Explosive Soil Concentrations at Vokes Range

AREA	SAMPLE	REPLICATE	[HMX] ppm	[RDX] ppm	[TNT] ppm
Main Grenade Blasting Area					
Four corners	VGR-A	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	0.29	n.d.
	VGR-B	A	n.d.	n.d.	n.d.
		B	n.d.	1.02	n.d.
		C	n.d.	-	n.d.
	VGR-C	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
	VGR-D	A	0.53	0.21	n.d.
		B	0.21	n.d.	n.d.
		C	0.02	n.d.	n.d.
	VGR-E	A	n.d.	n.d.	n.d.
		B	n.d.	0.13	n.d.
		C	n.d.	0.41	n.d.
	VGR-F	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
Blasting Pits					
	VGR-2	A	n.d.	0.18	n.d.
		B	n.d.	0.08	n.d.
		C	n.d.	0.12	n.d.
	VGR-3	A	n.d.	0.40	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	0.17	n.d.
	VGR-4	A	n.d.	2.75	n.d.
		B	n.d.	0.58	n.d.
		C	n.d.	1.08	n.d.
	VGR-5	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
	VGR-6	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.

n.d. : not detected

TABLE III

Explosive Soil Concentrations at The Soowahlie Rocket and Grenade Range (Old Antitank Range and Old Grenade Range)

AREA	SAMPLE	REPLICATE	[HMX] ppm	[RDX] ppm	[TNT] ppm
Old Antitank Range					
	OAR-1	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
	OAR-2	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
	OAR-3	A	5.89	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
	OAR-4	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
	OAR-5	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
	OAR-6	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
Old Grenade Range					
Surface A	OG-1	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
Deep A	OG-2	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
Surface B	OG-3	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.

AREA	SAMPLE	REPLICATE	[HMX] ppm	[RDX] ppm	[TNT] ppm
Deep B	OG-4	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
Surface C	OG-5	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
Deep C	OG-6	A	1.16	3.11	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	2.79	n.d.
Surface D	OG-7	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.
Deep D	OG-8	A	n.d.	n.d.	n.d.
		B	n.d.	n.d.	n.d.
		C	n.d.	n.d.	n.d.

n.d. : not detected

TABLE IV

Nitroglycerin Soil Concentrations at The Propellant Burning Area at Rocky Point

SAMPLE	CONCENTRATION (ppm)
PBA 1	< 1
PBA 2	< 1
PBA 3	< 1
PBA 4	40
PBA 5	5
PBA 6	30
PBA 7	< 1
PBA 9	< 1
PBA 10	< 1
PBA 11	10
PBA 12	90

Analyses from GC-ECD method

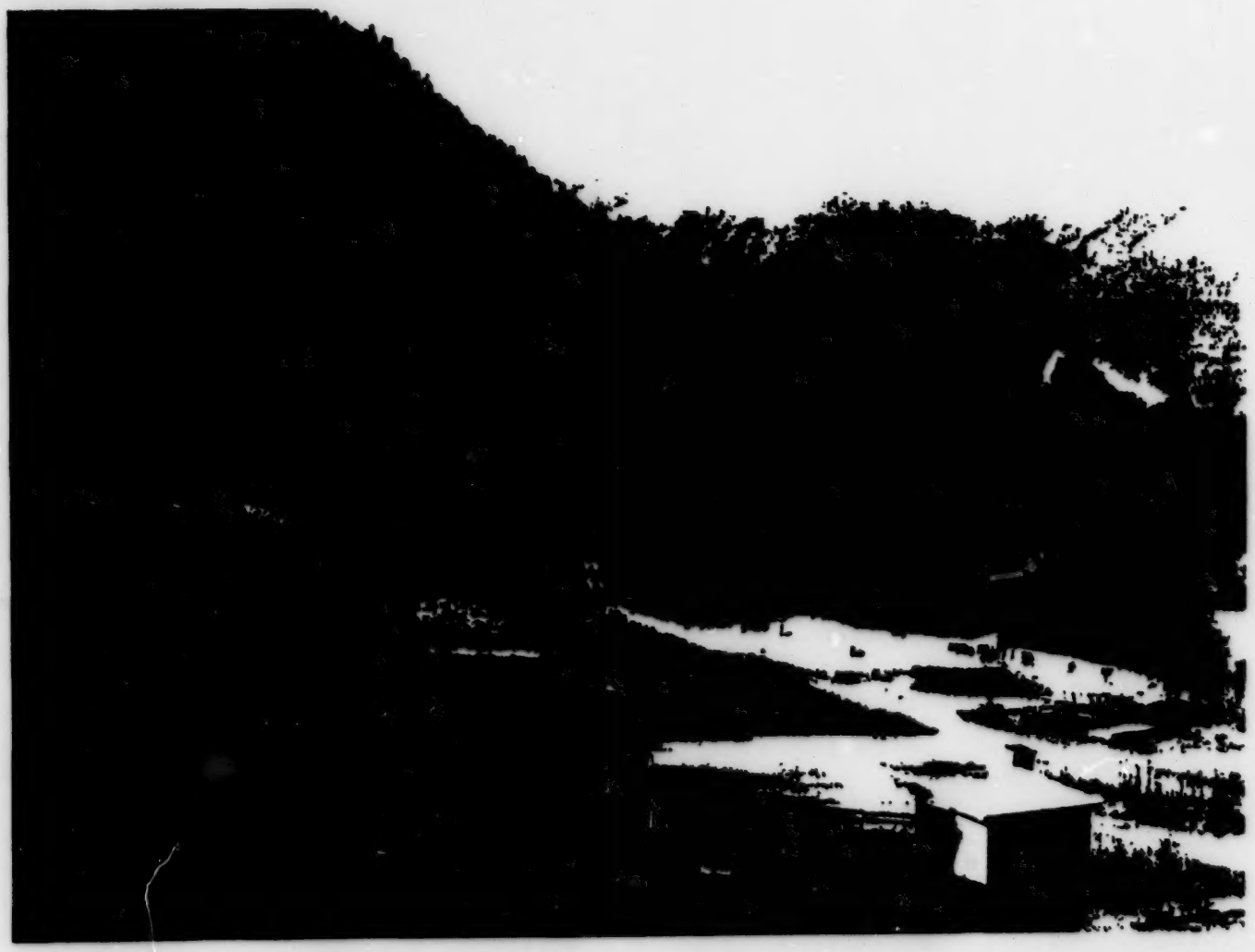

FIGURE 1A -Picture of the Slesse Range: Cratering (middle left), Wood Cutting (middle), and Concrete Cutting (middle right)

FIGURE 1B -Picture of the Slesse Range (view from the opposite side): Wood Cutting (center), Steel Cutting (upper middle left)

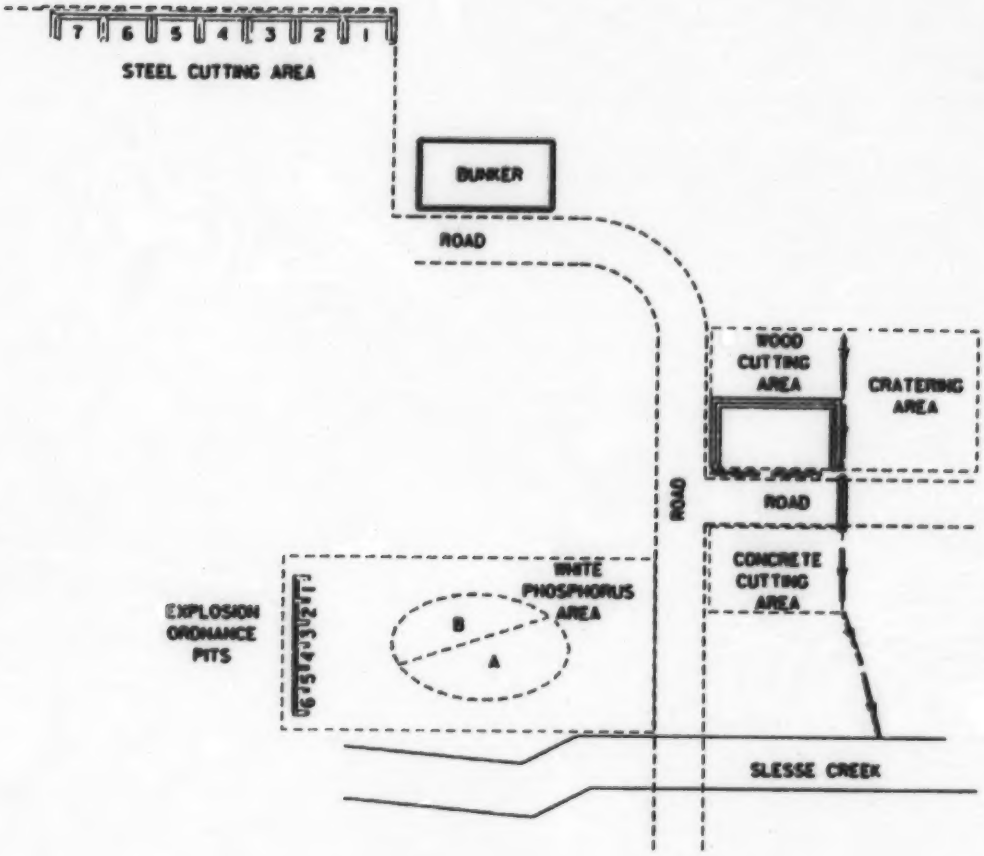

FIGURE 2A -Drawing of the different areas of the Slesse Range

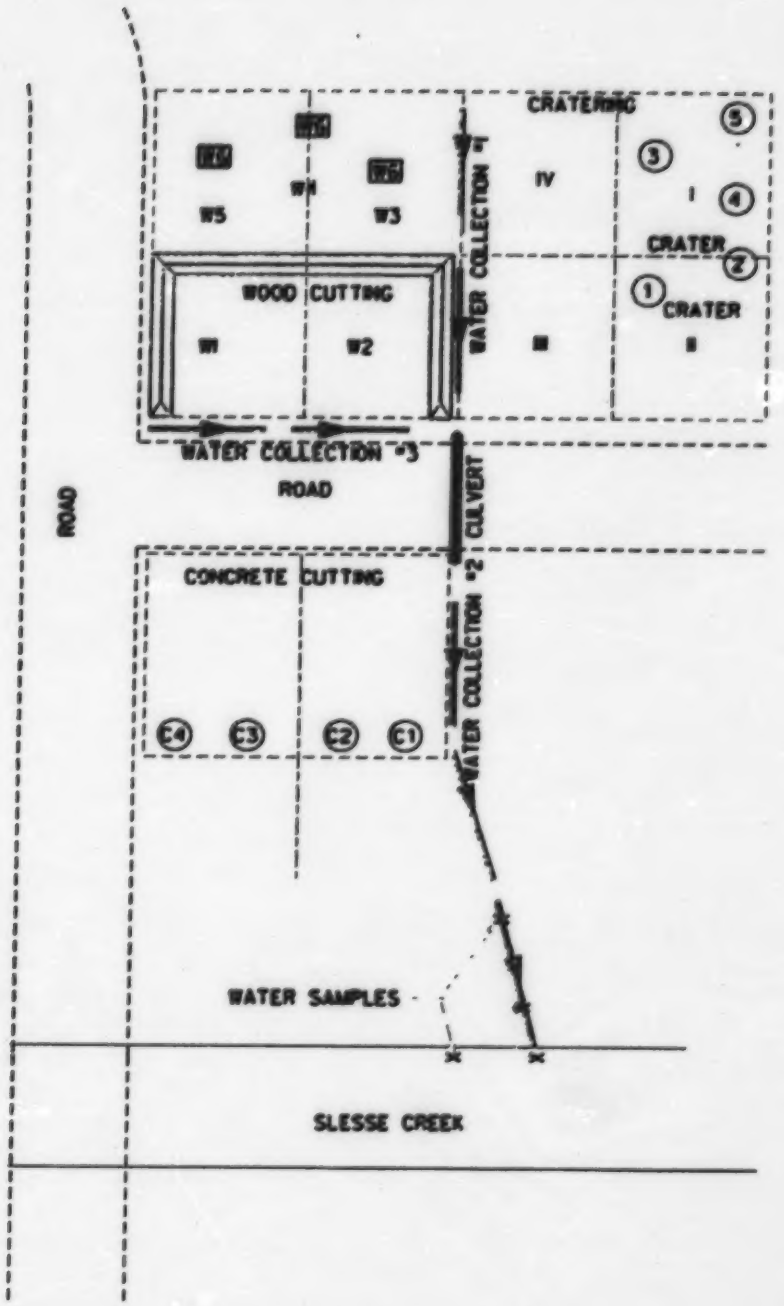

FIGURE 2B -Sampling strategy of the Main Area at the Slesse Range

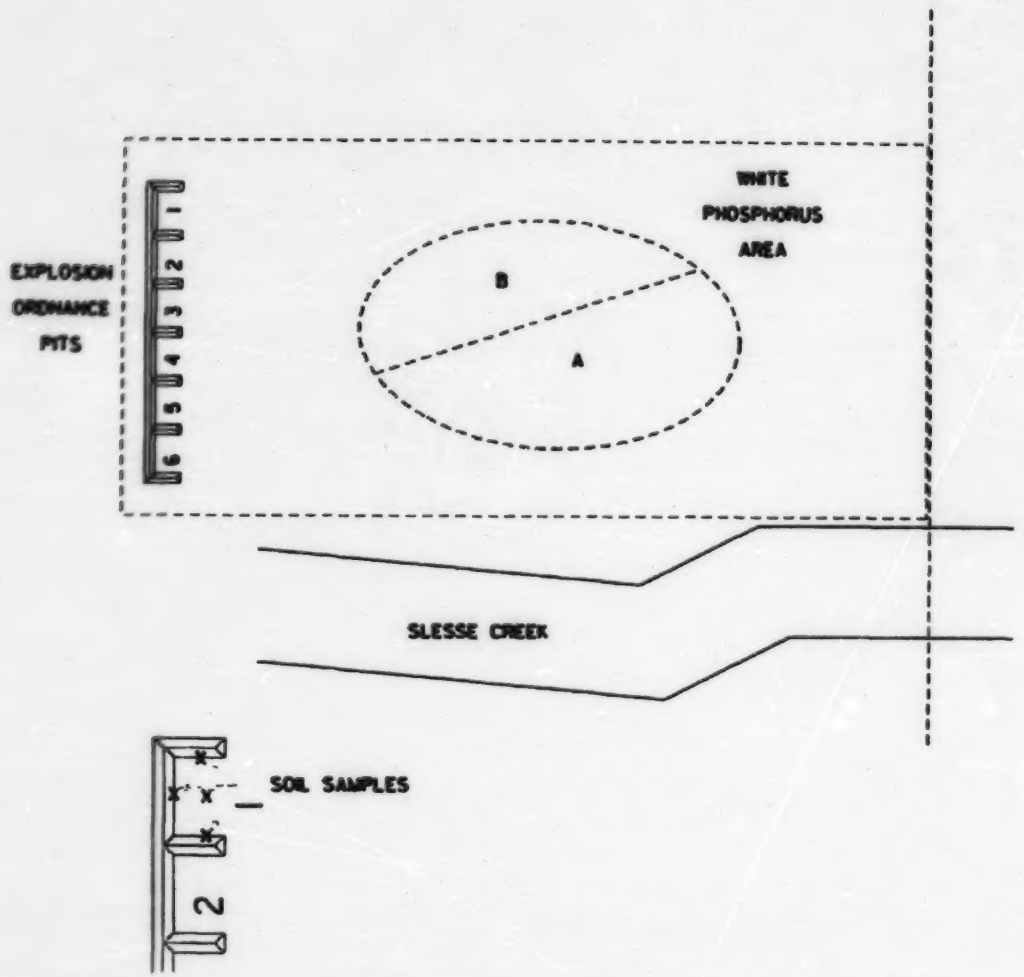

FIGURE 2C -Sampling strategy at the Ordnance Demolition Pits and White Phosphorus Areas at the Slesse Range

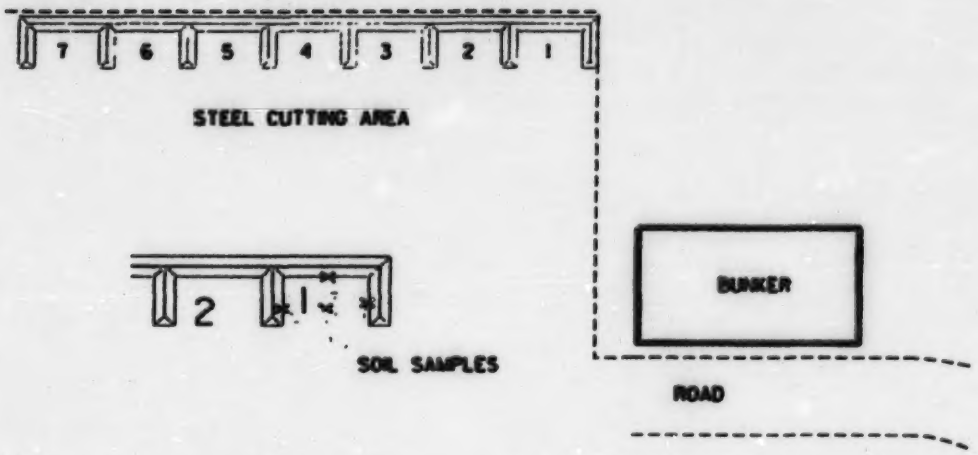

FIGURE 2D -Sampling strategy at the Steel Cutting Area of the Slesse Range

FIGURE 3 -Picture of a deep cratering hole in the Cratering Area (Slesse Range)

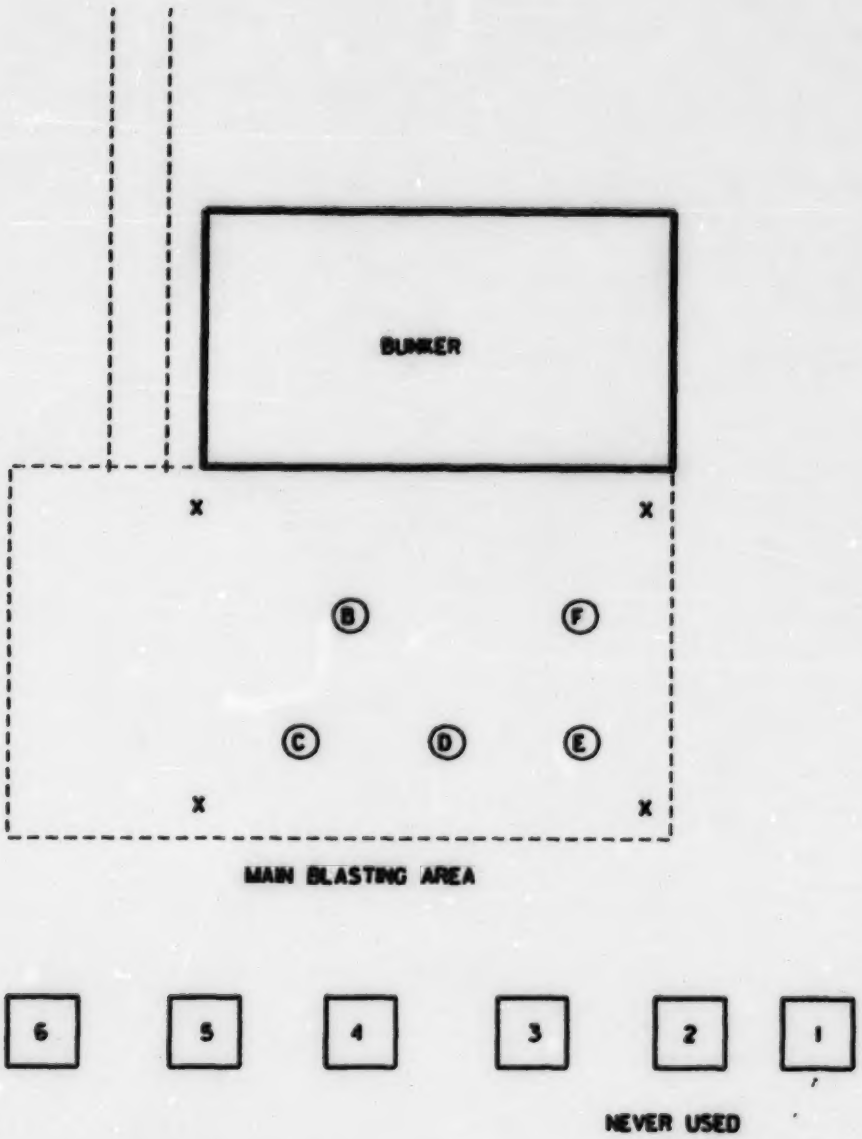

FIGURE 4 -Sampling strategy at the Vokes Grenade Range

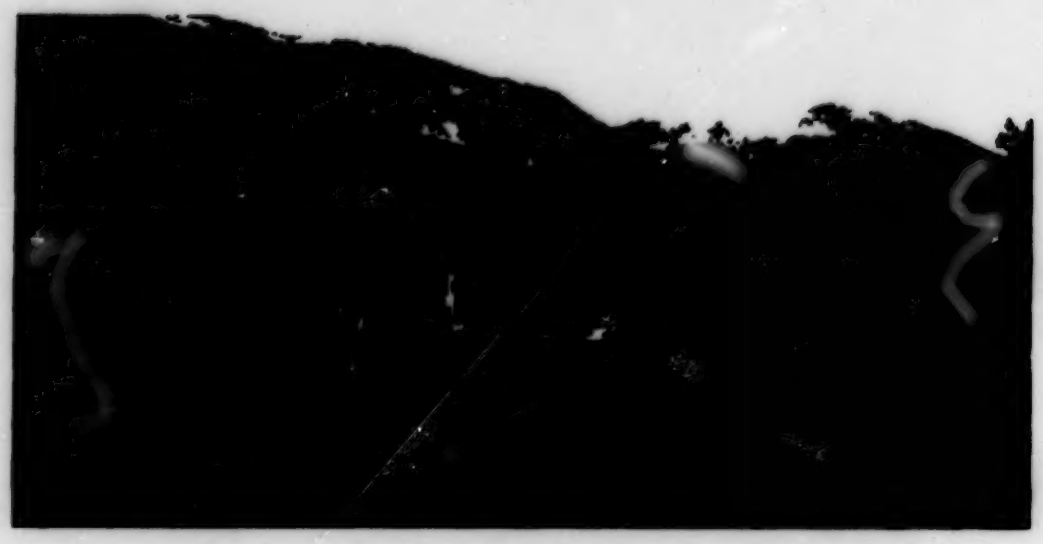

FIGURE 5 -Picture of the Protected Area at the Vokes Grenade Range

FIGURE 6 -Picture showing the sampling of the Blasting Area at the Vokes Grenade Range

FIGURE 7 -Picture of the Soowahlie Rocket Range (Old Antitank Range)

FIGURE 8 -Picture of a second view of the Soowahlie Rocket Range (Old Antitank Range)

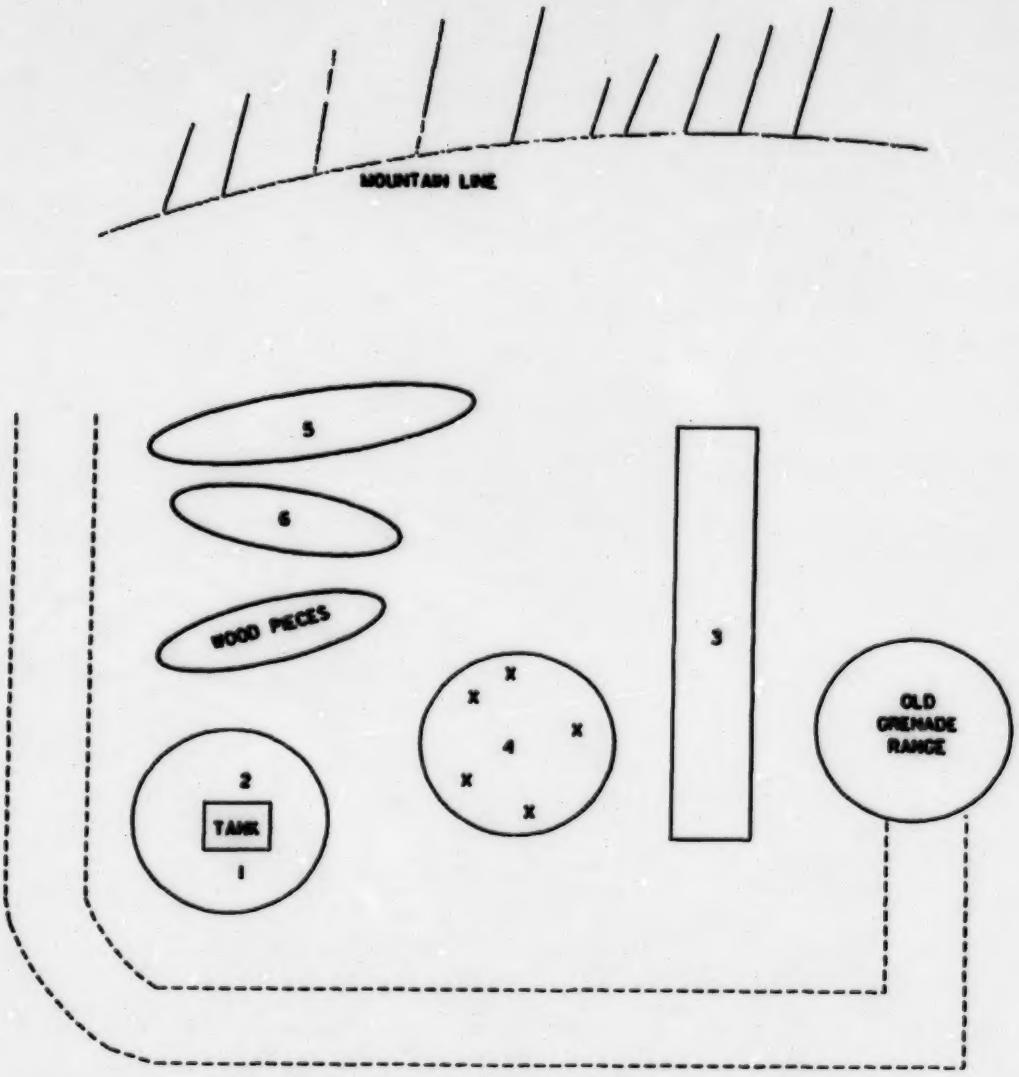

FIGURE 9 -Sampling strategy at the Soowahlie Rocket Range (Old Grenade Range)

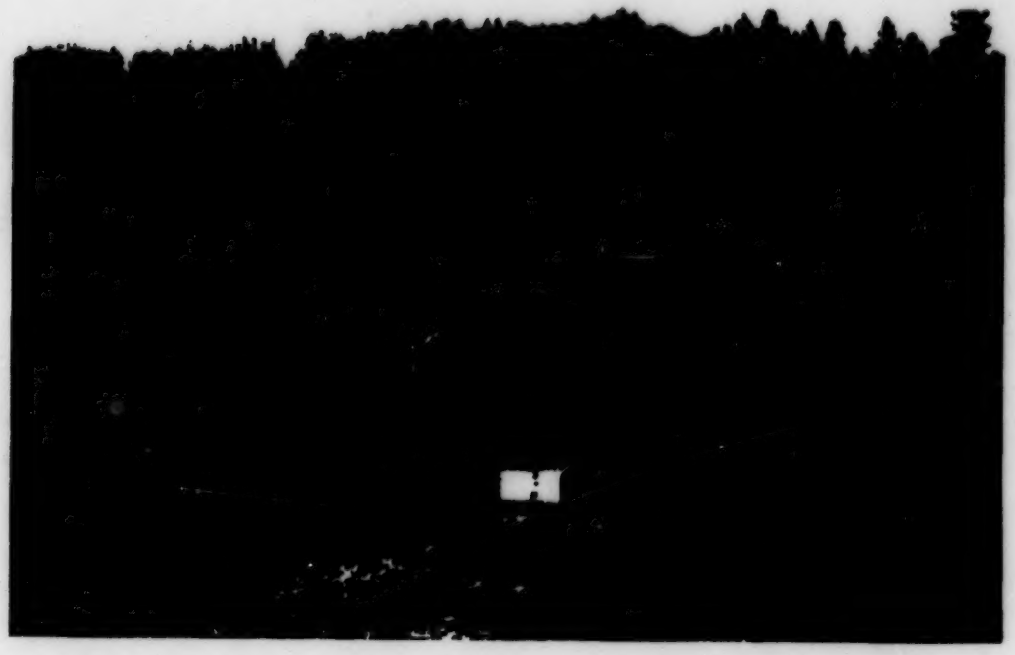

FIGURE 10 -Picture of the Soowahlie Grenade Range (Old Grenade Range)

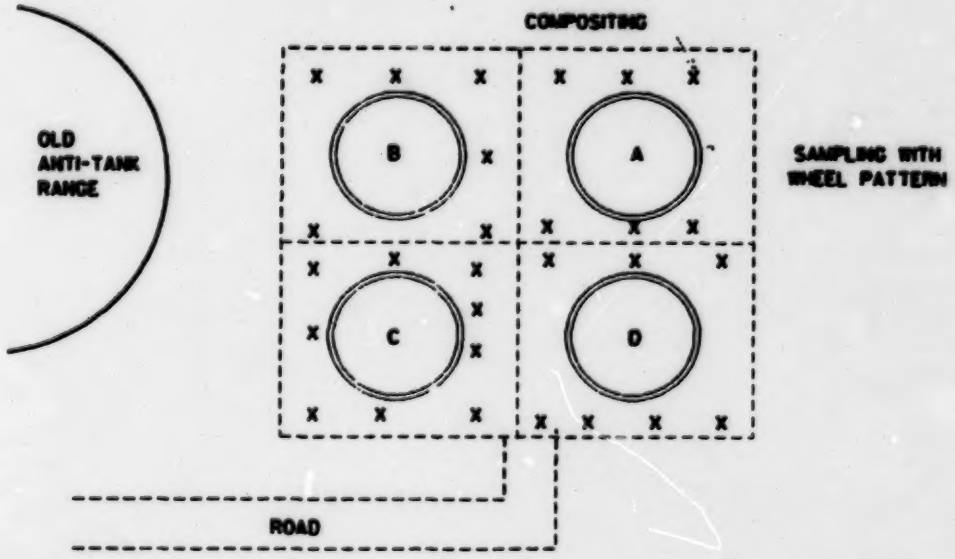

FIGURE 11 -Sampling strategy at the Soowahlie Grenade Range (Old Grenade Range)

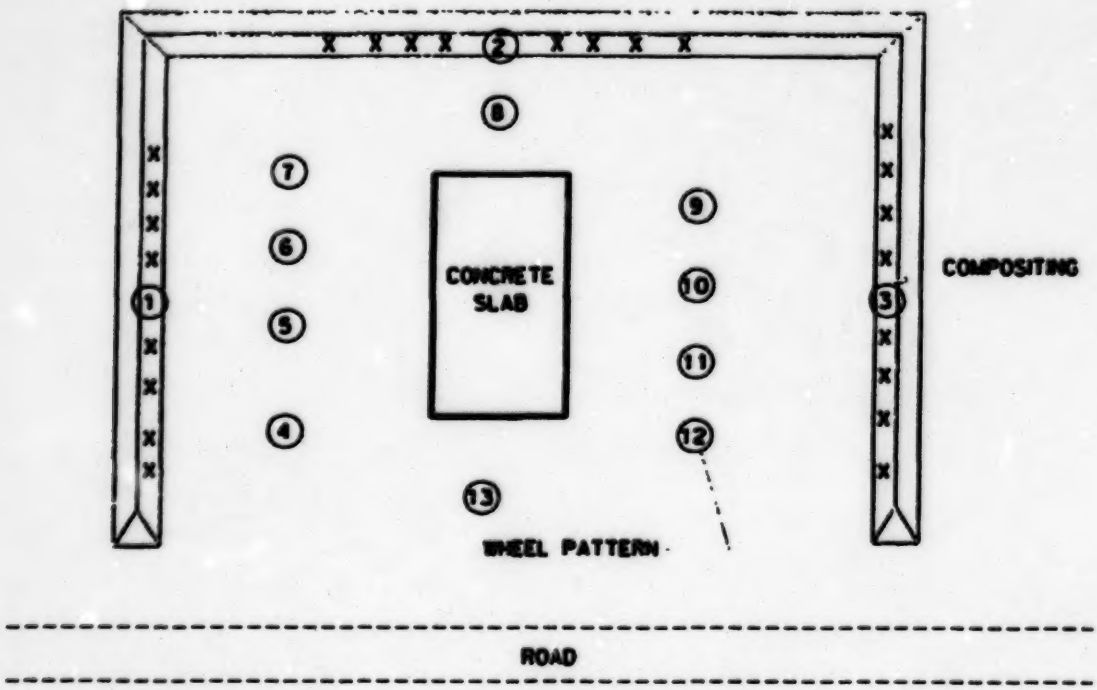

FIGURE 12 -Sampling strategy at the Propellants Burning area at CFAD Rocky Point

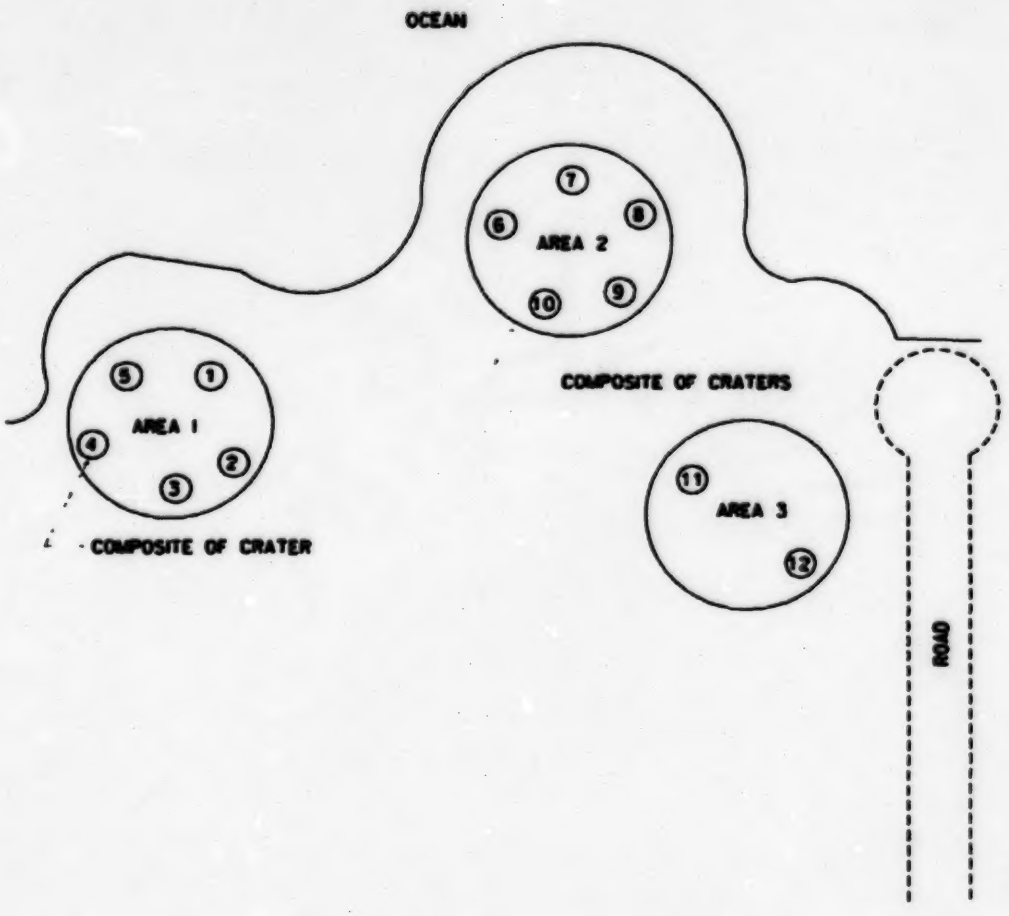

FIGURE 13 -Sampling strategy at the High Energy Open Detonation Area at CFAD Rocky Point

FIGURE 14 -Picture of the Propellants Burning Area at CFAD Rocky Point

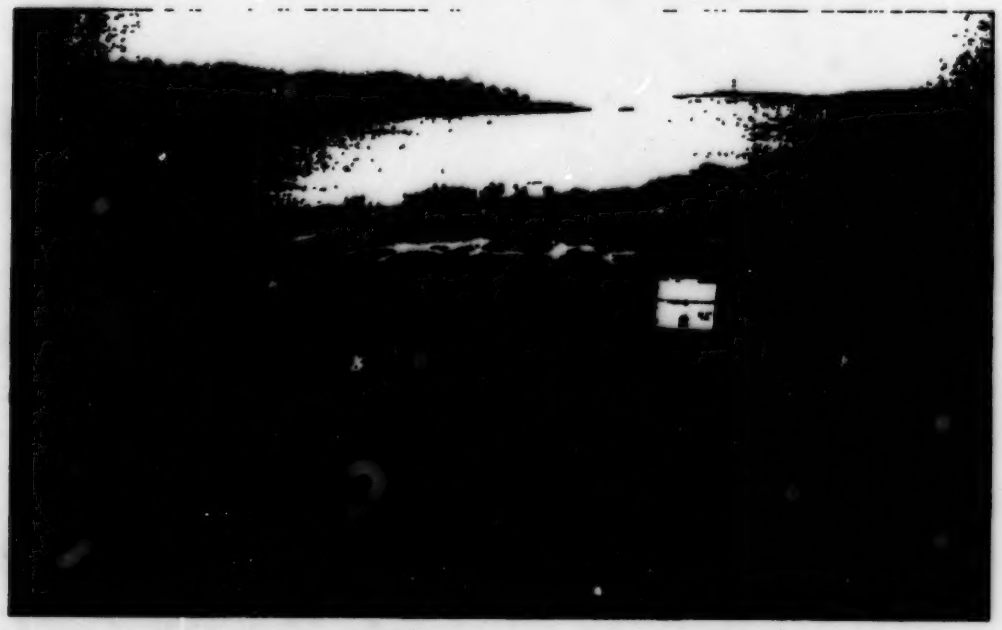

FIGURE 15 -Picture of the High Energy Open Detonation Area at CFAD Rocky Point

FIGURE 16 -Picture of unburned propellants grains at the Propellant Burning Area at CFAD Rocky Point

RAPPORT D'ANALYSE

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Air-Eau-Sol-Sédiment-Déchets
Expertises
Recherche et Développement
Contrôle de qualité

DOSSIER: 1-97-070
Centre de recherche pour la Défense - Défense Valcartier
- Analyses diverses

RAPPORT: No 5

MANDAT: Autorisation de Mme Sonia Thibeault
contrat: W7701-7-1563/001/XSK
dossier: XSK-7-00393
réquisition: W7701-7-1563

Prélèvements par le Centre de recherche pour la Défense

Échantillons de sol reçus le 18 août 1997

Analyses complétées le 12 septembre 1997

IDENTIFICATION DES ÉCHANTILLONS

NO DE LAB.	RÉFÉRENCE DU CLIENT
7 477	WP composite
7 478	PBA blanc
7 479	PBA 1
7 480	PBA 2
7 481	PBA 3
7 482	PBA 4
7 483	PBA 5
7 484	PBA 6
7 485	PBA 7
7 486	PBA 9
7 487	PBA 10
7 488	PBA 11
7 489	PBA 12
7 490	HE/OD crater comp.
7 491	HE/OD background
7 492	HE/OD 1
7 493	HE/OD 2
7 494	HE/OD 3
7 495	HE/OD 4
7 496	HE/OD 5
7 497	HE/OD 6
7 498	HE/OD 7
7 499	HE/OD 8
7 500	HE/OD 9
7 501	HE/OD 10
7 502	HE/OD 11
7 503	HE/OD 12

RÉSULTATS D'ANALYSES

PARAMÈTRES	ÉCHANTILLONS				MÉTHODES
	7 477	7 478	7 479	7 480	
Aluminium (mg/kg)	4 730	16 400	11 000	15 200	EPA SW 846 3050 ET 7000
Cadmium (mg/kg)	3,2	<1	<1	<1	EPA SW 846 3050 ET 7000
Chrome (mg/kg)	67	19	16	22	EPA SW 846 3050 ET 7000
Cuivre (mg/kg)	13 900	40,3	22,4	23,4	EPA SW 846 3050 ET 7000
Nickel (mg/kg)	128	17,0	14,0	18,0	EPA SW 846 3050 ET 7000
Plomb (mg/kg)	7 610	22,9	766	77,2	EPA SW 846 3050 ET 7000
Zinc (mg/kg)	13 800	42,3	83,6	47,7	EPA SW 846 3050 ET 7000
Mercure total (mg/kg)	0,985	0,053	0,157	<0,05	Anal. Meth Manual 80050

PARAMÈTRES	ÉCHANTILLONS				MÉTHODES
	7 481	7 482	7 483	7 484	
Aluminium (mg/kg)	15 000	15 600	16 300	13 300	EPA SW 846 3050 ET 7000
Cadmium (mg/kg)	<1	1,3	1,3	3,8	EPA SW 846 3050 ET 7000
Chrome (mg/kg)	25	29	30	32	EPA SW 846 3050 ET 7000
Cuivre (mg/kg)	24,5	57,2	45,0	53,7	EPA SW 846 3050 ET 7000
Nickel (mg/kg)	23,0	17,0	23,0	18,9	EPA SW 846 3050 ET 7000
Plomb (mg/kg)	796	33 200	13 400	50 800	EPA SW 846 3050 ET 7000
Zinc (mg/kg)	62,4	341	331	440	EPA SW 846 3050 ET 7000
Mercure total (mg/kg)	<0,05	0,15	1,56	0,61	Anal. Meth Manual 80050

PARAMÈTRES	ÉCHANTILLONS				MÉTHODES
	7 485	7 486	7 487	7 488	
Aluminium (mg/kg)	14 700	16 500	12 600	10 300	EPA SW 846 3050 ET 7000
Cadmium (mg/kg)	10,9	1,9	2,0	8,7	EPA SW 846 3050 ET 7000
Chrome (mg/kg)	110	30	26	44	EPA SW 846 3050 ET 7000
Cuivre (mg/kg)	435	62,8	34,0	34,1	EPA SW 846 3050 ET 7000
Nickel (mg/kg)	84,0	18,9	18,0	13,0	EPA SW 846 3050 ET 7000
Plomb (mg/kg)	21 500	15 900	33 500	220 000	EPA SW 846 3050 ET 7000
Zinc (mg/kg)	1 160	299	480	972	EPA SW 846 3050 ET 7000
Mercure total (mg/kg)	0,34	0,13	<0,05	<0,05	Anal. Meth Manual 80050

RÉSULTATS D'ANALYSES (suite)

PARAMÈTRES	ÉCHANTILLONS				MÉTHODES
	7 489	7 490	7 491	7 492	
Aluminium (mg/kg)	7 940	12 700	17 100	10 500	EPA SW 846 3050 ET 7000
Cadmium (mg/kg)	7,8	<1	<1	1,6	EPA SW 846 3050 ET 7000
Chrome (mg/kg)	72	20	20	19,9	EPA SW 846 3050 ET 7000
Cuivre (mg/kg)	75,8	47,6	32,3	35,9	EPA SW 846 3050 ET 7000
Nickel (mg/kg)	32,0	14,9	19,0	218	EPA SW 846 3050 ET 7000
Plomb (mg/kg)	60 700	18,4	<5	17,9	EPA SW 846 3050 ET 7000
Zinc (mg/kg)	977	45,2	53,3	32,8	EPA SW 846 3050 ET 7000
Mercure total (mg/kg)	<0,05	<0,05	<0,05	<0,05	Anal. Meth Manual 80050

PARAMÈTRES	ÉCHANTILLONS				MÉTHODES
	7 493	7 494	7 495	7 496	
Aluminium (mg/kg)	7 570	13 200	11 400	12 500	EPA SW 846 3050 ET 7000
Cadmium (mg/kg)	<1	<1	1,6	1,0	EPA SW 846 3050 ET 7000
Chrome (mg/kg)	17,9	21,6	22,0	20,0	EPA SW 846 3050 ET 7000
Cuivre (mg/kg)	31,5	36,2	42,2	33,0	EPA SW 846 3050 ET 7000
Nickel (mg/kg)	12,9	9,8	13,0	11,0	EPA SW 846 3050 ET 7000
Plomb (mg/kg)	32,8	109	23,5	13,8	EPA SW 846 3050 ET 7000
Zinc (mg/kg)	27,9	34,3	33,9	30,5	EPA SW 846 3050 ET 7000
Mercure total (mg/kg)	<0,05	<0,05	<0,05	<0,05	Anal. Meth Manual 80050

PARAMÈTRES	ÉCHANTILLONS				MÉTHODES
	7 497	7 498	7 499	7 500	
Aluminium (mg/kg)	13 500	11 500	10 900	11 300	EPA SW 846 3050 ET 7000
Cadmium (mg/kg)	1,4	1,4	1,1	1,7	EPA SW 846 3050 ET 7000
Chrome (mg/kg)	19,0	21,0	18,8	19,0	EPA SW 846 3050 ET 7000
Cuivre (mg/kg)	40,6	36,6	40,5	44,3	EPA SW 846 3050 ET 7000
Nickel (mg/kg)	10,0	18,0	15,9	17,0	EPA SW 846 3050 ET 7000
Plomb (mg/kg)	43,6	99,0	219	155	EPA SW 846 3050 ET 7000
Zinc (mg/kg)	40,4	41,2	38,7	52,0	EPA SW 846 3050 ET 7000
Mercure total (mg/kg)	<0,05	<0,05	<0,05	0,21	Anal. Meth Manual 80050

RÉSULTATS D'ANALYSES (suite)

PARAMÈTRES	ÉCHANTILLONS			MÉTHODES
	7 501	7 502	7 503	
Aluminium (mg/kg)	9 930	13 600	13 100	EPA SW 846 3050 ET 7000
Cadmium (mg/kg)	1,4	<1	1,1	EPA SW 846 3050 ET 7000
Chrome (mg/kg)	21,0	22,0	19,9	EPA SW 846 3050 ET 7000
Cuivre (mg/kg)	57,6	38,4	37,9	EPA SW 846 3050 ET 7000
Nickel (mg/kg)	17,0	14,0	8,0	EPA SW 846 3050 ET 7000
Plomb (mg/kg)	186	109	67,9	EPA SW 846 3050 ET 7000
Zinc (mg/kg)	52,0	32,4	34,0	EPA SW 846 3050 ET 7000
Mercure total (mg/kg)	0,15	0,10	0,056	Anal. Meth Manual 80050

PARAMÈTRES	ÉCHANTILLONS				MÉTHODE
	7 477	7 478	7 479	7 480	
Hydrocarbures aromatiques polycycliques (mg/kg)					EPA SW 846 3540, 3630, 8270
- Naphtalène	0,24	0,070	<0,05	<0,05	
- Acénaphtylène	<0,05	<0,05	<0,05	<0,05	
- Acénaphtène	0,074	<0,05	<0,05	<0,05	
- Fluorène	<0,05	<0,05	<0,05	<0,05	
- Phénanthrène	0,22	<0,05	<0,05	<0,05	
- Anthracène	<0,05	<0,05	<0,05	<0,05	
- Fluoranthène	0,22	<0,05	<0,05	<0,05	
- Pyrène	1,9	<0,05	<0,05	<0,05	
- Benzo (a) anthracène	<0,05	<0,05	<0,05	<0,05	
- Chrysène	0,12	<0,05	<0,05	<0,05	
- Benzo (c) phénanthrène	<0,05	<0,05	<0,05	<0,05	
- 7,12 diméthylbenzo (a) anthracène	<0,05	<0,05	0,11	<0,05	
- Benzo (b) + (j) fluoranthène + Benzo (k) fluoranthène	<0,05	<0,05	0,21	<0,05	
- Benzo (e) pyrène	<0,05	<0,05	0,082	<0,05	
- Benzo (a) pyrène	<0,05	<0,05	0,092	<0,05	
- 3-méthyl cholanthrène	<0,05	<0,05	0,098	<0,05	
- Indéno 1,2,3 cd pyrène	<0,05	<0,05	0,16	<0,05	
- Dibenzo (a,h) anthracène	<0,05	<0,05	0,16	<0,05	
- Benzo (g,h,i) périylène	<0,05	<0,05	0,18	<0,05	
- Dibenzo (a,l) pyrène	<0,05	<0,05	0,17	<0,05	
- Dibenzo (a,i) pyrène	<0,05	<0,05	<0,05	0,060	
- Dibenzo (a,h) pyrène	<0,05	<0,05	0,17	0,092	
Récupération (%):					
Acénaphthène - D10	Int.	125	153	119	
Chrysène - D12	159	83	156	155	
Anthracène - D10	151	128	128	115	

RÉSULTATS D'ANALYSES (suite)

PARAMÈTRES	ÉCHANTILLONS				MÉTHODE
	7 481	7 482	7 483	7 484	
Hydrocarbures aromatiques polycycliques (mg/kg)					EPA SW 846 3540, 3630, 8270
- Naphtalène	<0,05	<0,05	<0,06	<0,05	
- Acénaphtylène	<0,05	<0,05	<0,06	<0,05	
- Acénaphtène	<0,05	<0,05	<0,06	<0,05	
- Fluorène	<0,05	<0,05	<0,06	<0,05	
- Phénanthrène	<0,05	0,057	<0,06	0,079	
- Anthracène	<0,05	<0,05	<0,06	<0,05	
- Fluoranthène	<0,05	<0,05	<0,06	<0,05	
- Pyrène	<0,05	<0,05	<0,06	<0,05	
- Benzo (a) anthracène	<0,05	<0,05	<0,06	<0,05	
- Chrysène	<0,05	<0,05	<0,06	<0,05	
- Benzo (c) phénanthrène	<0,05	<0,05	<0,06	<0,05	
- 7,12 diméthylbenzo (a) anthracène	<0,05	<0,05	<0,06	<0,05	
- Benzo (b) + (j) fluoranthène + Benzo (k) fluoranthène	<0,05	<0,05	<0,06	<0,05	
- Benzo (e) pyrène	<0,05	<0,05	<0,06	<0,05	
- Benzo (a) pyrène	<0,05	<0,05	<0,06	<0,05	
- 3-méthyl cholanthrène	<0,05	<0,05	<0,06	<0,05	
- Indéno 1,2,3 cd pyrène	<0,05	<0,05	<0,06	<0,05	
- Dibenzo (a,h) anthracène	<0,05	<0,05	<0,06	<0,05	
- Benzo (g,h,i) périylène	<0,05	<0,05	<0,06	<0,05	
- Dibenzo (a,l) pyrène	<0,05	<0,05	<0,06	<0,05	
- Dibenzo (a,i) pyrène	<0,05	<0,05	<0,06	<0,05	
- Dibenzo (a,h) pyrène	<0,05	<0,05	<0,06	<0,05	
Récupération (%):					
Acénaphthène - D10	94	133	Int.	149	
Chrysène - D12	125	131	Int.	Int.	
Anthracène - D10	91	110	141	122	

RÉSULTATS D'ANALYSES (suite)

PARAMÈTRES	ÉCHANTILLONS				MÉTHODE
	7 485	7 486	7 487	7 488	
Hydrocarbures aromatiques polycycliques (mg/kg)					EPA SW 846 3540, 3630, 8270
- Naphtalène	0,074	<0,05	<0,05	<0,05	
- Acénaphtylène	<0,05	<0,05	<0,05	<0,05	
- Acénaphtène	<0,05	<0,05	<0,05	<0,05	
- Fluorène	<0,05	<0,05	<0,05	<0,05	
- Phénanthrène	0,43	0,055	0,089	0,34	
- Anthracène	<0,05	<0,05	<0,05	<0,05	
- Fluoranthène	0,36	<0,05	<0,05	0,11	
- Pyrène	0,39	<0,05	<0,05	0,14	
- Benzo (a) anthracène	0,11	<0,05	<0,05	<0,05	
- Chrysène	0,24	<0,05	<0,05	0,19	
- Benzo (c) phénanthrène	<0,05	<0,05	<0,05	<0,05	
- 7,12 diméthylbenzo (a) anthracène	<0,05	<0,05	<0,05	<0,05	
- Benzo (b) + (j) fluoranthène + Benzo (k) fluoranthène	0,092	<0,05	<0,05	<0,05	
- Benzo (e) pyrène	<0,05	<0,05	<0,05	<0,05	
- Benzo (a) pyrène	<0,05	<0,05	<0,05	<0,05	
- 3-méthyl cholanthrène	<0,05	<0,05	<0,05	<0,05	
- Indéno 1,2,3 cd pyrène	<0,05	<0,05	<0,05	<0,05	
- Dibenzo (a,h) anthracène	<0,05	<0,05	<0,05	<0,05	
- Benzo (g,h,i) périylène	<0,05	<0,05	<0,05	<0,05	
- Dibenzo (a,l) pyrène	<0,05	<0,05	<0,05	<0,05	
- Dibenzo (a,l) pyrène	<0,05	<0,05	<0,05	<0,05	
- Dibenzo (a,h) pyrène	<0,05	<0,05	<0,05	<0,05	
Récupération (%):					
Acénaphthène - D10	156	153	173	126	
Chrysène - D12	122	Int.	148	132	
Anthracène - D10	121	129	139	109	

RÉSULTATS D'ANALYSES (suite)

PARAMÈTRES	ÉCHANTILLONS				MÉTHODE
	7 489	7 490	7 491	7 492	
Hydrocarbures aromatiques polycycliques (mg/kg)					EPA SW 846 3540, 3630, 8270
- Naphtalène	0,11	<0,05	<0,06	<0,05	
- Acénaphtylène	<0,05	<0,05	<0,06	<0,05	
- Acénaphtène	<0,05	<0,05	<0,06	<0,05	
- Fluorène	0,055	<0,05	<0,06	<0,05	
- Phénanthrène	0,88	<0,05	<0,06	<0,05	
- Anthracène	<0,05	<0,05	<0,06	<0,05	
- Fluoranthène	0,24	<0,05	<0,06	<0,05	
- Pyrène	0,36	<0,05	<0,06	<0,05	
- Benzo (a) anthracène	0,10	<0,05	<0,06	<0,05	
- Chrysène	0,22	<0,05	<0,06	<0,05	
- Benzo (c) phénanthrène	<0,05	<0,05	<0,06	<0,05	
- 7,12 diméthylbenzo (a) anthracène	<0,05	<0,05	<0,06	<0,05	
- Benzo (b) + (j) fluoranthène + Benzo (k) fluoranthène	0,081	<0,05	<0,06	<0,05	
- Benzo (e) pyrène	<0,05	<0,05	<0,06	<0,05	
- Benzo (a) pyrène	<0,05	<0,05	<0,06	<0,05	
- 3-méthyl cholanthrène	<0,05	<0,05	<0,06	<0,05	
- Indéno 1,2,3 cd pyrène	<0,05	<0,05	<0,06	<0,05	
- Dibenzo (a,h) anthracène	<0,05	<0,05	<0,06	<0,05	
- Benzo (g,h,i) pérylène	0,062	<0,05	<0,06	<0,05	
- Dibenzo (a,l) pyrène	<0,05	<0,05	<0,06	<0,05	
- Dibenzo (a,i) pyrène	<0,05	<0,05	<0,06	<0,05	
- Dibenzo (a,h) pyrène	<0,05	<0,05	<0,06	<0,05	
Récupération (%):					
Acénaphthène - D10	127	Int.	121	88	
Chrysène - D12	131	116	175	107	
Anthracène - D10	115	90	90	77	

RÉSULTATS D'ANALYSES (suite)

PARAMÈTRES	ÉCHANTILLONS				MÉTHODE
	7 493	7 494	7 495	7 496	
Hydrocarbures aromatiques polycycliques (mg/kg)					EPA SW 846 3540, 3630, 8270
- Naphtalène	<0,05	<0,05	<0,05	<0,05	
- Acénaphtylène	<0,05	<0,05	<0,05	<0,05	
- Acénaphtène	<0,05	<0,05	<0,05	<0,05	
- Fluorène	<0,05	<0,05	<0,05	<0,05	
- Phénanthrène	<0,05	<0,05	<0,05	<0,05	
- Anthracène	<0,05	<0,05	<0,05	<0,05	
- Fluoranthène	<0,05	<0,05	<0,05	<0,05	
- Pyrène	<0,05	<0,05	<0,05	<0,05	
- Benzo (a) anthracène	<0,05	<0,05	<0,05	<0,05	
- Chrysène	<0,05	<0,05	<0,05	<0,05	
- Benzo (c) phénanthrène	<0,05	<0,05	<0,05	<0,05	
- 7,12 diméthylbenzo (a) anthracène	<0,05	<0,05	<0,05	<0,05	
- Benzo (b) + (j) fluoranthène + Benzo (k) fluoranthène	0,17	<0,05	<0,05	<0,05	
- Benzo (e) pyrène	0,063	<0,05	<0,05	<0,05	
- Benzo (a) pyrène	0,067	<0,05	<0,05	<0,05	
- 3-méthyl cholanthrène	0,097	<0,05	<0,05	<0,05	
- Indéno 1,2,3 cd pyrène	<0,05	<0,05	<0,05	<0,05	
- Dibenzo (a,h) anthracène	0,091	<0,05	<0,05	<0,05	
- Benzo (g,h,i) pérylène	0,089	<0,05	<0,05	<0,05	
- Dibenzo (a,l) pyrène	0,088	<0,05	<0,05	<0,05	
- Dibenzo (a,i) pyrène	0,18	0,087	<0,05	<0,05	
- Dibenzo (a,h) pyrène	0,22	<0,05	<0,05	<0,05	
Récupération (%):					
Acénaphthène - D10	93	90	76	77	
Chrysène - D12	102	116	100	100	
Anthracène - D10	91	82	83	74	

RÉSULTATS D'ANALYSES (suite)

PARAMÈTRES	ÉCHANTILLONS				MÉTHODE
	7 497	7 498	7 499	7 500	
Hydrocarbures aromatiques polycycliques (mg/kg)					EPA SW 846 3540, 3630, 8270
- Naphtalène	<0,05	<0,05	<0,05	<0,05	
- Acénaphtylène	<0,05	<0,05	<0,05	<0,05	
- Acénaphtène	<0,05	<0,05	<0,05	<0,05	
- Fluorène	<0,05	<0,05	<0,05	<0,05	
- Phénanthrène	<0,05	<0,05	<0,05	<0,05	
- Anthracène	<0,05	<0,05	<0,05	<0,05	
- Fluoranthène	<0,05	<0,05	<0,05	<0,05	
- Pyrène	<0,05	<0,05	<0,05	<0,05	
- Benzo (a) anthracène	<0,05	<0,05	<0,05	<0,05	
- Chrysène	<0,05	<0,05	<0,05	<0,05	
- Benzo (c) phénanthrène	<0,05	<0,05	<0,05	<0,05	
- 7,12 diméthylbenzo (a) anthracène	<0,05	<0,05	<0,05	<0,05	
- Benzo (b) + (j) fluoranthène + Benzo (k) fluoranthène	<0,05	<0,05	<0,05	<0,05	
- Benzo (e) pyrène	<0,05	<0,05	<0,05	<0,05	
- Benzo (a) pyrène	<0,05	<0,05	<0,05	<0,05	
- 3-méthyl cholanthrène	<0,05	<0,05	<0,05	<0,05	
- Indéno 1,2,3 cd pyrène	<0,05	<0,05	<0,05	<0,05	
- Dibenzo (a,h) anthracène	<0,05	<0,05	<0,05	<0,05	
- Benzo (g,h,i) périylène	<0,05	<0,05	<0,05	<0,05	
- Dibenzo (a,l) pyrène	<0,05	<0,05	<0,05	<0,05	
- Dibenzo (a,i) pyrène	<0,05	<0,05	<0,05	<0,05	
- Dibenzo (a,h) pyrène	<0,05	<0,05	<0,05	<0,05	
Récupération (%):					
Acénaphthène - D10	91	87	102	92	
Chrysène - D12	127	105	158	136	
Anthracène - D10	93	80	81	83	

RÉSULTATS D'ANALYSES (suite)

PARAMÈTRES	ÉCHANTILLONS			MÉTHODE
	7 501	7 502	7 503	
Hydrocarbures aromatiques polycycliques (mg/kg)				EPA SW 846 3540, 3630, 8270
- Naphtalène	<0,05	<0,05	<0,05	
- Acénaphtylène	<0,05	<0,05	<0,05	
- Acénaphtène	<0,05	<0,05	<0,05	
- Fluorène	<0,05	<0,05	<0,05	
- Phénanthrène	<0,05	<0,05	<0,05	
- Anthracène	<0,05	<0,05	<0,05	
- Fluoranthène	<0,05	<0,05	<0,05	
- Pyrène	<0,05	<0,05	<0,05	
- Benzo (a) anthracène	<0,05	<0,05	<0,05	
- Chrysène	<0,05	<0,05	<0,05	
- Benzo (c) phénanthrène	<0,05	<0,05	<0,05	
- 7,12 diméthylbenzo (a) anthracène	<0,05	<0,05	<0,05	
- Benzo (b) + (j) fluoranthène + Benzo (k) fluoranthène	<0,05	<0,05	<0,05	
- Benzo (e) pyrène	<0,05	<0,05	<0,05	
- Benzo (a) pyrène	<0,05	<0,05	<0,05	
- 3-méthyl cholanthrène	<0,05	<0,05	<0,05	
- Indéno 1,2,3 cd pyrène	<0,05	<0,05	<0,05	
- Dibenzo (a,h) anthracène	<0,05	<0,05	<0,05	
- Benzo (g,h,i) pérylène	<0,05	<0,05	<0,05	
- Dibenzo (a,l) pyrène	<0,05	<0,05	<0,05	
- Dibenzo (a,i) pyrène	<0,05	<0,05	<0,05	
- Dibenzo (a,h) pyrène	<0,05	<0,05	<0,05	
Récupération (%):				
Acénaphthène - D10	89	95	87	
Chrysène - D12	151	113	123	
Anthracène - D10	79	91	85	

DATE: Le 12 septembre 1997

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CHIMISTE
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88-039
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AT CFB CHILLIWACK AND CFAD ROCKY POINT (U)

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A sampling campaign was done at CFB Chilliwack to evaluate the contamination by explosives at different local demolition ranges. Three ranges including Sleese, Vokes and the Sooweihle Rocket and grenade ranges were sampled using the pre-screening immuno-assay method but most of the collected soils and water samples were shipped to DREV for a thorough HPLC analysis. At the Sleese range, the ion mobility spectrometry technology developed by CPAD Technologies was evaluated and compared as a tool for the field screening of explosives in soils and water. The technology worked but suffers strong limitations due to the quantity sampled and to the sensitivity of the detector. Most of the open detonation activities including cratering, grenade, concrete, wood and steel cutting done at the ranges were evaluated and showed low levels of explosive contamination. Sampling of the white phosphorus burning area revealed no contamination by explosives as foreseen. An exception was observed in the Ordnance Destruction Pits area at Sleese range where higher levels of contamination were observed. At CFAD Rocky Point, it was observed that the open burning of obsolete gun propellants is a dirty process and should be modified. Nitroglycerine analyses revealed important levels of contamination and heavy metals analyses showed lead concentrations higher than the level C threshold. Action is therefore required at that site. At the high energy open detonation site (Rocky Point), no contamination by explosives was found. Recommendations regarding all these sites were made.

Un campagne d'échantillonnage a été faite à la BFC Chilliwack pour évaluer la contamination par les explosifs à différents sites locaux de démolition. Trois sites incluant le site Sleese, Vokes et les sites Sooweihle de tir anti-char et de grenades furent échantillonnés en utilisant la méthode de pré-échantillonnage par immuno essais mais la plupart des échantillons de sols et d'eau furent expédiés au CRDV pour être analysés par CLHP. Au site de Sleese, la technologie de spectrométrie par mobilité ionique développée par CPAD Technologies fut évaluée et comparée à titre d'outil pour l'échantillonnage sur place des explosifs dans les sols et l'eau. La technologie fonctionne mais souffre d'inconvénients majeurs dus à la quantité analysée et à la sensibilité du détecteur. La plupart des activités de détonation extérieure telles que la formation de cratères, les grenades, le coupage du ciment, du bois et de l'acier effectuées aux sites furent évaluées et ont démontré des niveaux faibles de contamination par les explosifs. L'échantillonnage du site de brûlage de phosphore blanc n'a pas démontré de contamination par les explosifs tel qu'anticipé. Une exception a été observée dans les enclaves de destruction de munitions au site de Sleese où des niveaux de contamination plus importants ont été observés. Au DMFC de Rocky Point, il a été observé que le brûlage extérieur de poudres à canon désuètes est un procédé sale et qu'il doit être modifié. Les analyses de nitroglycérine ont démontré des niveaux importants de contamination et les analyses des métaux lourds ont montré des concentrations de plomb plus élevées que le critère C. Une intervention est requise à ce site. Au site de détonation extérieure des matériaux haute énergie de Rocky Point, aucune contamination par les explosifs n'a été trouvée. Des recommandations concernant tous ces sites ont été faites.

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